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Abstracts from
International Workshop on
Soft Matter Physics & Complex Flows

Svolvær, Lofoten, Norway May 22-25, 2012

Edited bv Jon Otto Fossum and Elisabeth Bouchaud

The scope of the workshop included a variety of topics such as:

Complex fluids - soft matter phenomena - microfluidics - soft matter in reduced dimensions - granular media - adhesion - sorption - self-organization phenomena - flow and transport phenomena – porous media physics

Invited speakers included:

Igor Aronson (*Argonne Nat. Lab., Chicago, USA*)
Denis Bartolo (*ESPCI-Paris, France*)
Daniel Bonn (*Univ. Amsterdam, Netherlands*)
Heloisa Bordallo (*NBI, Univ. Copenhagen, Denmark*)
Francoise Brochard-Wyart (*Inst. Curie, Paris, France*)
Yves Couder (*Univ. Paris 7, France*)
Julien Delahaye (*Neel Institute, Grenoble, France*)
Paul Dommersnes (*CAS-Oslo/Univ. Paris 7, France*)
Antônio M. Figueiredo Neto (*USP, São Paulo, Brazil*)
Ivar Giaever (*CAS-Oslo/Renneslaer Univ. USA*)
Mogens Høegh Jensen (*NBI Copenhagen, Denmark*)
Grethe Vestergaard Jensen (*Århus Univ. Denmark*)
Aldo Jesorka (*Chalmers Univ. Sweden*)
Tom Henning Johansen (*CAS-Oslo /Univ. Oslo, Norway*)
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Paul Meakin (*Univ. Idaho, USA*)
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Ritva Serimaa (*Univ. Helsinki, Finland*)
Arne Skjeltorp (*CAS-Oslo/IFE, Norway*)
Niclas Solin (*Linköping Univ., Sweden*)
Tuomas Tallinen (*Univ. Jyväskylä Finland/Harvard USA*)
Renaud Toussaint (*CAS-Oslo/Univ. Strasbourg, France*)
Giovani Vasconcelos (*UFPE, Recife, Brazil*)
Jørn Inge Vestgården (*Univ. Oslo, Norway*)
Jun Zhang (*New York Univ., USA*)

complexphysics.org
ISBN 978-82-93224-11-2

Abstracts from

International Workshop on

Soft Matter Physics & Complex Flows

Lofoten, Norway, May 22-25, 2012

Edited by
Jon Otto Fossum and Elisabeth Bouchaud

Foreword:

Welcome to the International Workshop on Soft matter Physics & Complex Flows in Svolvær, Lofoten, Norway, May 22-25, 2012.

This workshop is part of the Norwegian *Complex* Network[1] 2011-12 project at Center for Advanced Stydy – CAS[2] at the Norwegian Academy of Science and Letters in Oslo, and it is the last in a series of workshops[3] arranged by the Complex Network during 2011-12.

The present workshop on *Soft matter Physics & Complex Flows* in Svolvær, is a joint workshop between the CAS project, and a Nordforsk funded Network on Soft Matter Physics[4]. This network (called NordSoft) which is coordinated from the Norwegain University of Science and Technology in Trondheim, consists of about 100 researchers from the Nordic countries[5]. In addition to organizing workshops, the Nordforsk network also includes funding for exhcange of researchers in between the particiating groups. The present workshop is the second workshop organized by this Nordforsk network, following a kick-off event held at Aarhus University in Denmark, June 28 – July 1, 2011.

Soft matter physics is experiencing these days a renewed interest partly because of its importance at the frontier between biology, physics and chemistry as well as in materials science. New phenomena can be tuned in composite and complex systems which are often bearing properties half way between those of solids and liquids, thus including complex flows. The relevance of the field spans from the physics and chemistry of biology, materials, the environment and energy, to geology. Emergent complex phenomena at different length- and time- scales, and universal behaviors across disciplines are central to this field. Soft and complex matter physics is a cross-disciplinary field, and this is clearly represented by the collection of talks and posters presented at this workshop.

The opening session of the workshop took place on a boat bringing the participants from Bodø to Svolvær, where the rest of the workshop took place. The organizers have tried to divide the presentations into topics, and for example you will in the opening session find topics relevant to physics that may be experienced during such a boat trip.

With this, we welcome you to the wonderful nature of Lofoten, and we hope the participants enjoyed some unforgettable days in the midnight sun together with us.

Elisabeth Bouchaud
Jon Otto Fossum

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[1] www.complexphysics.org

[2] www.cas.uio.no

[3] Aug. 29 - Sept. 2, 2011: *International Workshop on Complex Phenomena in Superconductors & Magnetic Systems,* Hardangerfjord hotel, Øystese, Norway.

Sept. 26, 2011: *Kickoff, Complex Matter Physics*, CAS, Oslo, Norway.

Jan. 31- Feb. 3, 2012: *2nd International Workshop on Complex Physical Phenomena in Materials*, Porto de Galinhas, Brazil.

Feb. 6-7, 2012: *International Mini-Workshop on Complex Flows*, Int, Center for Condensed Matter Physics (ICCMP), University of Brasilia (UnB), Brazil.

March 6-9, 2012: *MarchCOMeeting'12, Complex matter physics: materials, dynamics and patterns*, Havana, Cuba.

May 15 – 19, 2012: International Workshop on *Quantum Systems in Complex environments,* CAS, Oslo, Norway

[4] www.nordforsk.org/en/programs/prosjekter/nordic-network-in-soft-matter-physics?set_language=en and

[5] *Denmark* (University of Copenhagen, Roskilde University, Aarhus University),

Finland (University of Helsinki, Tampere University of Technology),

Norway (University of Oslo. Institute for Energy Technology – IFE at Kjeller, the Norwegian University of Science and Technology – NTNU in Trondheim),

Sweden (Uppsala University, Linköping University, Chalmers University of Technology in Gothenborg, Linköping University, Maxlab at Lund University).

Invited speakers included:
Igor Aronson (*Argonne Nat. Lab., Chicago, USA*)
Denis Bartolo (*ESPCI-Paris, France*)
Daniel Bonn (*Univ. Amsterdam, Netherlands*)
Heloisa Bordallo (*NBI, Univ. Copenhagen, Denmark*)
Francoise Brochard-Wyart (*Inst. Curie, Paris, France*)
Yves Couder (*Univ. Paris 7, France*)
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Tuomas Tallinen (*Univ. Jyväskylä Finland/Harvard USA*)
Renaud Toussaint (*CAS-Oslo/Univ. Strasbourg, France*)
Giovani Vasconcelos (*UFPE, Recife, Brazil*)
Jørn Inge Vestgården (*Univ. Oslo, Norway*)
Jun Zhang (*New York Univ., USA*)

Organizing committee:
Jon Otto Fossum (*CAS-Oslo /NTNU-Trondheim, Norway*)
Elisabeth Bouchaud (*CAS-Oslo/ESPCI-Paris, France*)
Knut Jørgen Måløy (*CAS-Oslo/Univ. Oslo, Norway*)

Scientific advisory committee:
Eirik Grude Flekkøy (*CAS-Oslo/Univ. Oslo, Norway*)
Yuri Galperin (*CAS-Oslo /Univ. Oslo, Norway*)
Jan Skov Pedersen (*Univ. Århus, Denmark*)
Adrian Rennie (*Univ. Uppsala, Sweden*)
Ritva Serimaa (*Univ. Helsinki, Finland*)
Arne Skjeltorp (*CAS-Oslo/IFE, Kjeller, Norway*)

Opening at boat MS Vågsfjord:

Jon Otto Fossum

Elisabeth Bouchaud

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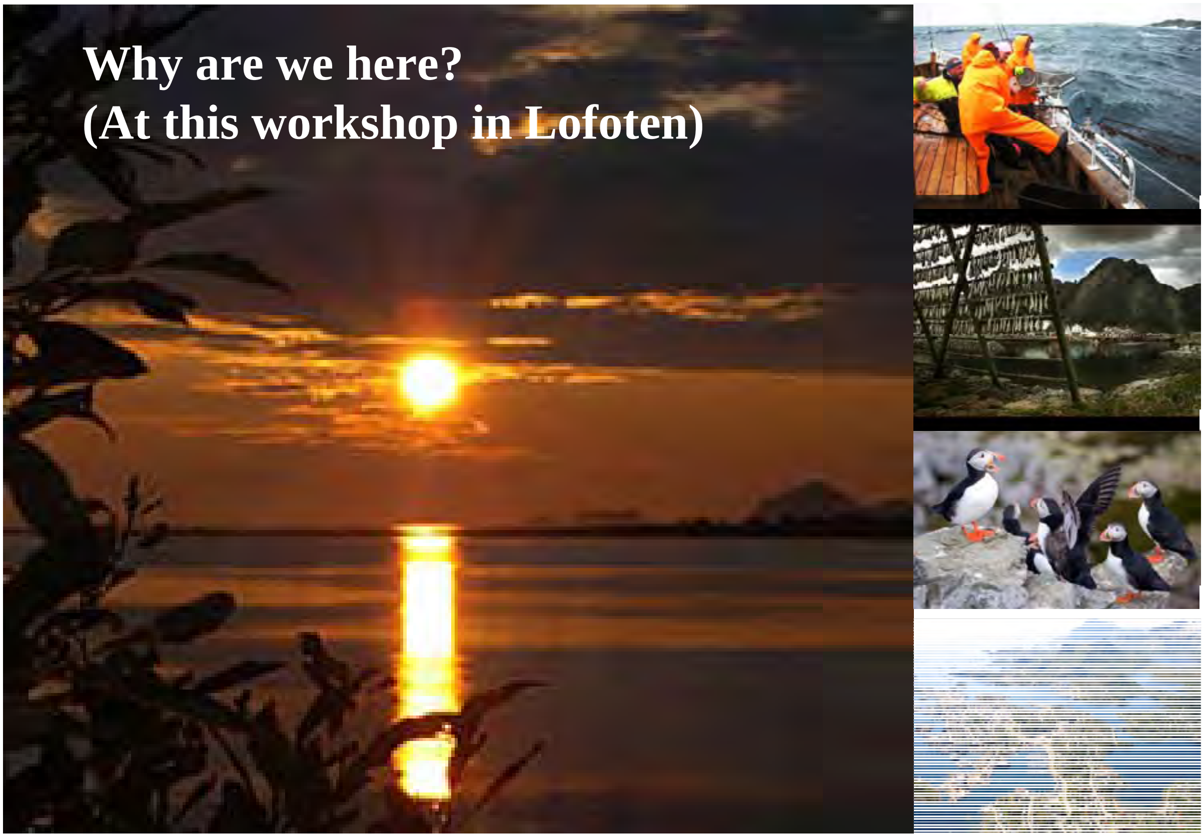
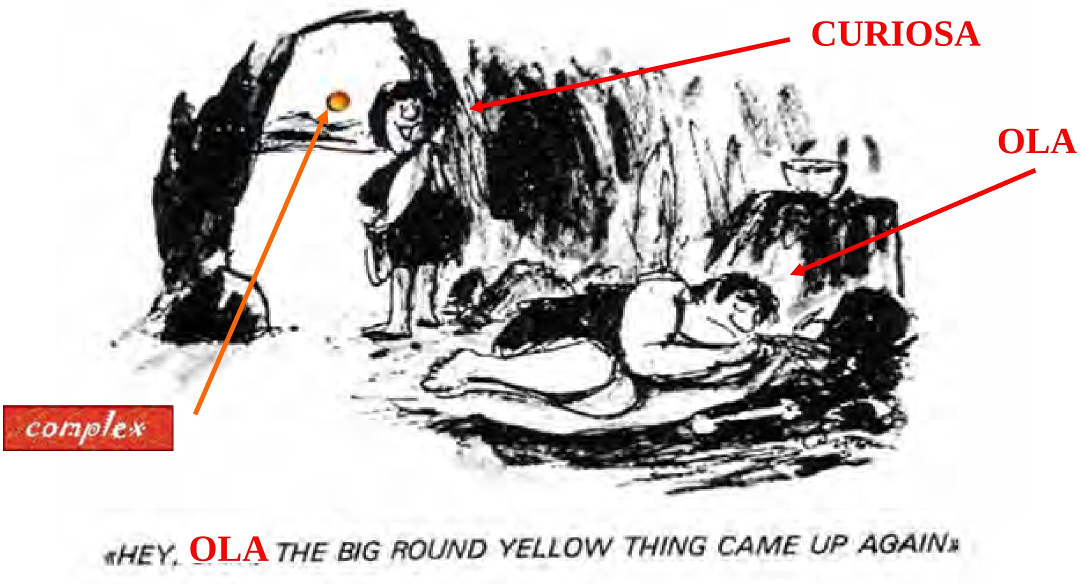


Why are we here?
(<u>fex.</u> At this workshop in Lofoten)

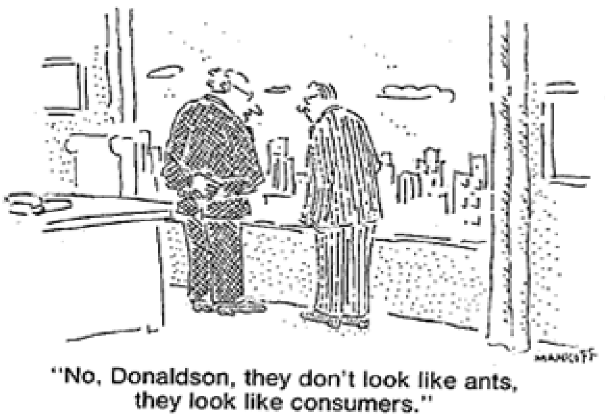


To ask and answer some basic questions in the light of Complexity

Leo Kadanoff wrote:

To extract physical knowledge from a complex system, one must focus on the right level of description

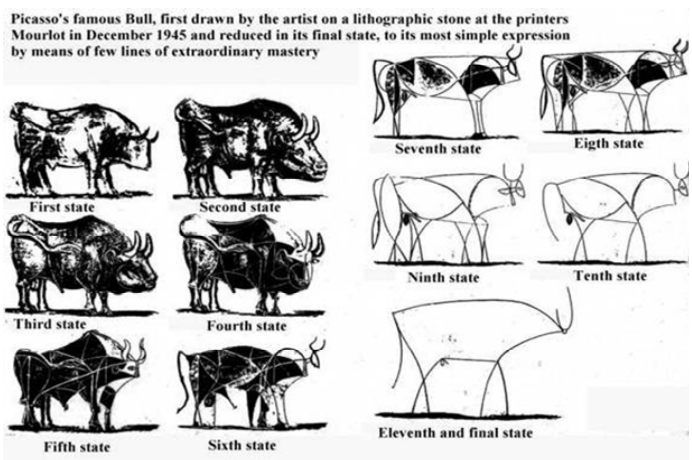
from the right level of observation.
(Jon Otto Fossum)



Right level of observation:

Bug

Removal of redundancy



SHORT PROGRAM:

	Tuesday May 22	Wednesday May 23	Thursday May 24
0700-0900		Breakfast	Breakfast
0900-0920		Bordallo	Figuereido
0920-0940		Vestergaard Jensen	Tallinen
0940-1000		Pynn	Mathiesen
1000-1020		Dommersnes	Santucci
1020-1050		Coffeebreak	Coffeebreak
1050-1110		Meakin	Meheust
1110-1130		Bonn	Toussaint
1130-1150		Juanes	Vasconcelos
1150-1210		Sandnes	Rothman
1210-1230		Delahaye	Organized excursion including lunch, dinner and discussions
1230-1400		Lunch	
1400-1420		Brochard	
1420-1440		Serimaa	
1440-1500		Bartolo	
1500-1520	Registration. Boat MS Vågsfjord departs from Bodø harbor 1530	Jesorka	
1520-1540		Solin	
1540-1550		Zhang	
1550-1600	Opening		
1600-1610		Giaever	
1610-1620	Høegh Jensen		
1620-1630		Coffeebreak	
1630-1650	Couder		
1650-1710	Rennie	Aronson	
1710-1800	Coffeebreak Boat arrival in Svolvær 1800	Poster presentations	
1800-1840	Checkin Thon Hotel Svolvær	Poster session	
1840-1900	Johansen		
1900-1920	Vestgården		
1920-1940	Ortiz		
1940-2000	Skjeltorp		
2000-2200	Dinner	Dinner	
2200-	Discussions	Discussions	

Venues:

MS Vågsfjord:

Thon Hotel Svolvær:

DETAILED PROGRAM:

Tuesday May 22:		
On boat: MS Vågsfjord **Chair: Jon Otto Fossum** (NTNU, Norway)	**1500-1530**	**Registration** in **boat** at Bodø harbor. Name of boat: **MS Vågsfjord**
	1530	**MS Vågsfjord** (boat) departs from Bodø harbor. Destination: Svolvær
	1550-1610	**Jon Otto Fossum/Elisabeth Bouchaud:** *Opening remarks/practical information*
	1610-1630	**Mogens Høegh Jensen:** (NBI Copenhagen, Denmark) *Modeling Plankton in Turbulence*
	1630-1650	**Yves Couder:** (Univ. Paris 7, France) *A "double solution" in the classical wave-particle duality of walkers*
	1650-1710	**Adrian Rennie:** (Univ. Uppsala, Sweden) *Self-assembly and Order of Colloidal Particles at Interfaces and under Flow*
	1710-1800	**Coffeebreak**
	1800	**Boat arrives Svolvær**
In Thon Hotel Svolvær **Chair: Elisabeth Bouchaud** (ESPCI, Paris, France)	**1800-1840**	**Check-in Thon Hotel Svolvær**
	1840-1900	**Tom Henning Johansen:** (Univ. Oslo, Norway) *Particle manipulation using mobile magnetic domain walls*
	1900-1920	**Jørn Inge Vestgården:** (Univ. Oslo, Norway) *Analysis of paramagnetic micro-bead ratchets: The saddle point approach*
	1920-1940	**Wilson Ortiz:** (UFSCAR – SP, Brazil) *Morphology of flux avalanches in superconducting films*
	1940-2000	**Arne Skjeltorp:** (IFE, Norway) *Hydrodynamic analogies to electricity and magnetism: The fascinating life and scientific work of Carl A. Bjerknes*
	2000-2200	**Dinner in Thon Hotel Svolvær**
Anywhere	**2200-**	**Discussions in the midnight sun**


Wednesday May 23:

In Thon Hotel Svolvær **Chair: Jan Skov Pedersen** (Aarhus Univ., Denmark)	**0700-0900**	**Breakfast in Thon Hotel Svolvær**
	0900-0920	**Heloisa Bordallo:** (NBI, Copenhagen, Denmark) *Exploiting the use of quasi-elastic neutron scattering to understand confinement: From water motion in cement, pastes and clays to molecular drugs*
	0920-0940	**Grethe Vestergaard Jensen:** (Aarhus Univ., Denmark) *Time-resolved Synchrotron SAXS Study of Micelle Formation*
	0940-1000	**Roger Pynn:** (Indiana Univ., USA) *Probing Depletion-Induced Correlations in a Colloidal Fluid*
	1000-1020	**Paul Dommersnes:** (Univ. Paris 7 , France) *Clay-oil drops in electric fields*
	1020-1050	**Coffebreak**
In Thon Hotel Svolvær **Chair: Eirik Grude Flekkøy** (Univ. Oslo, Norway)	**1050-1110**	**Paul Meakin:** (Idaho Nat. Lab., USA/PGP, Oslo/IFE, Norway) *Pattern formation in granular materials: Martian "spiders" and partially fluidized bimodal mixtures*
	1110-1130	**Daniel Bonn:** (Univ. Amsterdam, Netherlands) *Why is granular rheology so complicated?*
	1130-1150	**Ruben Juanes:** (MIT, USA) *Fingering and fracturing in granular media*
	1150-1210	**Bjørnar Sandnes:** (Univ. Swansea, UK) *Granular mixtures on a slope*
	1210-1230	**Julien Delahaye:** (Inst. Néel, Grenoble, France) *Electrical glassy behaviour in granular aluminium thin films*
	1230-1400	**Lunch in Thon Hotel Svolvær**
In Thon Hotel Svolvær **Chair: Kenneth D. Knudsen** (IFE, Norway)	**1400-1420**	**Françoise Brochard-Wyart:** (Inst. Curie, Paris, France) *Dynamics of membrane pores*
	1420-1440	**Ritva Serimaa:** (Univ. Helsinki, Finland) *Studies on the hierarchical structure of plant cell wall and biomometic natural polymer based composites*
	1440-1500	**Denis Bartolo:** (ESPCI, Paris, France) *Traffic flows in microfluidic networks*
	1500-1520	**Aldo Jesorka:** (Chalmers Univ., Gothenburg, Sweden) *A Multi-Purpose Microfluidic Pipette for Localized Superfusion*
	1520-1540	**Niclas Solin:** (Linköping Univ. Sweden) *Preparation of Functionalized Amyloid-like Materials*
	1540-1600	**Jun Zhang:** (New York Univ., USA) *Fluid Ratchets and Biolocomotion*
	1600-1620	**Ivar Giaever:** (Applied Biophysics Inc., Troy. USA) *Nanotechnology, Biology and Business*
	1620-1650	**Coffeebreak**
	1650-1710	**Igor Aronson:** (Argonne Nat. Lab., Chicago, USA) *Active Magnetic Colloids: From Self-Assembled Swimmers to Simple Robots*
In Thon Hotel Svolvær	**1710-1800**	**Poster presentations:** Poster presenters line up, and present their poster(s), 2 minutes each, max 2 slides per poster.
	1800-2000	**Poster session** including refreshments
	2000-2200	**Dinner in Thon Hotel Svolvær**
Anywhere	**2200-**	**Discussions in the midnight sun**

Thursday May 24:

In Thon Hotel Svolvær **Chair: Yuri Galperin** (Univ. Oslo, Norway)	**0700-0900**	**Breakfast in Thon Hotel Svolvær**
	0900-0920	**Antonio M. Figueiredo Neto:** (USP, Sao Paulo, Brazil) Mechano-optical properties of elastomers and ferroelastomers
	0920-0940	**Tuomas Tallinen:** (Harvard, USA/Univ. Jyväskylä, Finland) *Compression driven pattern formation in soft solids*
	0940-1000	**Joachim Mathiesen:** (NBI, Copenhagen, Denmark) *Pattern formation in stressed multi-phase systems*
	1000-1020	**Stephane Santucci:** (ENS-Lyon, France) *Crackling Noise during the failure of heterogeneous materials*
	1020-1050	**Coffebreak**
In Thon Hotel Svolvær **Chair: Knut Jørgen Måløy** (Univ. Oslo, Norway)	**1050-1110**	**Yves Meheust:** (Univ. Rennes 1, France) *Flow in fractured geological media: the influence of fracture scale heterogeneity*
	1110-1130	**Renaud Toussaint:** (Univ. Strasbourg, France) *Capillary pressure/saturation relationships in a diphasic flow in a random medium: Influence of the boundary conditions*
	1130-1150	**Giovani Vasconcelos:** (UFPE, Recife, Brazil) *Fingers and bubbles in a Hele-Shaw cell: Exact solutions and the selection problem*
	1150-1210	**Dan Rothman:** (MIT, USA) *Growth and Ramification of Stream Networks*
Organized excursion	**1230**	**2 buses** (with guides) depart from Thon Hotel Svolvær. Destination: **Lofotr – Viking Museum at Borg** (www.lofotr.no)
	1330	Welcome to **Lofotr – Viking Museum at Borg**, which is a full scale reconstruction of a viking farm that was located in this place, the largest viking farm ever found.
	1330-1430	**Lunch at Lofotr – Viking Museum at Borg**
	1430-1530	Viking history and information at Lofotr – Viking Museum at Borg
	1530	**2 buses** depart from Lofotr – Viking Museum at Borg. Destination: The fishing village **Henningsvær**. ("Venice of Lofoten": www.henningsvar.com)
	1615	Welcome to **Henningsvær.**
	1615-1715	Optional visit to the Seafood Export Company: **Riksheim Henningsvær AS: Tasting of local seafood products. Refreshements.**
	1715-1900	Split into 2 groups for tour of Henningsvær, partly guided, partly on your own.
	1900	**Tansport (boat or bus)** departs from Henningsvær. Destination: The old trading post **Kalle** (www.kalle.no/galleri/kalle_i_lofoten)
	2000	Transport (boat or bus) arrives at the old trading post Kalle.
	2000-2300	"After Sea" **dinner in Kalle** includes prepared, and self-grilled food from local ingredients, with the help of local hosts.
	~2300	**2 buses** depart for return to Thon Hotel Svolvær
	~2330	Arrival Thon Hotel Svolvær
Anywhere	**~2330-**	**Discussions in the midnight sun**

POSTER PRESENTERS (21 posters):

Luiza Angelutha (Univ. Oslo, Norway)
Extreme value statistics in avalanches near depinning transition
Rene Castberg (Univ. Oslo, Norway)
Electric field alignment of polarized Clay particles
Fabiano Colauto (UFSCAR – Sao Carlos - SP, Brazil)
Flux avalanches and its suppression by electromagnetic braking
Marion Erpelding (Univ. Oslo, Norway)
Steady-state, simultaneous two-phase flow in porous media: History-(in)dependence experiments.
Irep Gozen (Chalmers Univ., Gothenburg, Sweden)
Repair of large area pores in solid supported double bilayers
Henrik Hemmen (NTNU, Trondheim, Norway)
Carbon dioxide intercalation in a clay at near-ambient conditions
Inkeri Kontro (Univ. Helsinki, Finland)
The Structure of The Bacterial Cell Wall and the Native S-layer
Maxime Lefranc (ESPCI, Paris, France)
Toward a macroscopic and microscopic description of fracture in dense colloidal suspensions in the vicinity of their glass transition
Elisabeth Lindbo Hansen (NTNU, Trondheim, Norway)
Swelling transition of a clay induced by heating
Pavlo Mikheenko (Univ. Oslo, Norway)
Combined voltage and magneto-optical study of the vortex flow in superconducting films
Michael Niebling (Univ. Oslo, Norway)
Numerical Studies of Aeorfractures in Porous Media
Zbigniew Rozynek (NTNU, Trondheim, Norway)
Soil Clay Oil Suspensions Subjected to Electric Field
Tomas Plivelic (Maxlab, Lund Univ., Sweden)
Solid State Structural Characterization of Biobased Materials
Dorthe Posselt (Roskilde Univ. Denmark)
Structural changes in block copolymer thin films during solvent vapour treatment
Baudouin Saintyves (CEA-Saclay, France)
Bulk fingering instabilities in a soft solid and in a complex fluid
Bjørnar Sandnes (Swansea Univ., UK)
Pattern palette for complex fluid flows
Arne Skjeltorp (IFE, Norway)
Self-assembly and symbolic dynamics
Pawel Sobas (IFE, Norway)
Dynamic Light Scattering measurements of clay materials in liquid CO_2
Ken Tore Tallakstad (Univ. Oslo, Norway)
The survival of fat tail exponents during up-scaling in disordered interface systems
Renaud Toussaint (Univ. Strasbourg, France)
Influence of chemistry and climate on large induced large scale stresses in anisotropically fractured carbonates.
Max Wolff (Univ. Uppsala, Sweden)
The solid-liquid boundary as seen by scattering

TALKS

Request to speakers:
Make it simple, you are speaking to non-specialists.

Igor Aronson

Active Magnetic Colloids: From Self-Assembled Swimmers to Simple Robots

Self-assembly, a natural tendency of simple building blocks to organize into complex architectures is a unique opportunity for contemporary materials science. In order to support structural complexity and functional diversity, self-assembled materials must actively consume energy and “live” out of equilibrium. We study a simple active colloidal system: a ferromagnetic colloidal suspension confined at the interface between two immiscible liquids and energized by an alternating magnetic field. Depending on the frequency and amplitude of magnetic field, a variety of dynamic self-assembled structures is observed: from self-propelled magnetic swimmers - magnetic snakes to localized asters and arrays of asters. Locomotion can be further controlled by a small magnetic field applied parallel to the interface. The asters, remotely controlled by an external magnetic field, perform simple robotic functions including capture, transport, and positioning of target particles. Observed phenomena are described by a first-principles mathematical model for the dynamic self-assembly of magnetic colloids at a water-air interface. The ability to manipulate colloidal structures is crucial for the further development of self-assembled microrobots.

Igor Aronson

Denis Bartolo

Traffic flows in microfluidic networks

I will present two sets of recent results on the traffic of particles flowing in prototypal microfluidic networks. Firstly, I will report on the collective dynamics of particle streams cruising through ordered obstacle networks. A special emphasis will be put on the hydrodynamic destabilization of the streams and on the subsequent network invasion. Secondly, I will show a combination of theoretical and experimental results on the traffic of microfluidic droplets advected through extended loop-networks. Connections with other one-dimensional transport processes will be put forward.

Denis Bartolo

Daniel Bonn

Institute of Physics, University of Amsterdam, The Netherlands

Why is granular rheology so complicated?"

According to the famous book on granular rheology by Duran, the transport and handling of granular materials is responsible for about 10% of the world energy consumption. It is therefore of paramount importance to understand the rheology of such systems. However, there seems to be little consensus in the litterature on the flow properties of especially dense gransular systems. I will show why this is so by using a combination of global rheology and MRI measurements of local density and velocity profiles. Since for dense systems the viscosity depends very strongly on volume fraction, very small variations in the latter have a huge impact on the measured flow properties. If this is taken into account, a much clearer picture of granular rheology emerges.

Daniel Bonn

Heloisa Bordallo

Niels Bohr Institute, University of Copenhagen

Exploiting the use of quasi-elastic neutron scattering to understand confinement: From water motion cement pastes and clays to molecular drugs

In this talk I will present results on studies using quasi-elastic neutron scattering (QENS) aimed at understanding fluid transmission. The focus of the presentation will be on aqueous interfaces in clays and confined water in the nano- and micro-pores of concrete. So far our studies have provided valuable insights into the water transport through clay barriers under different conditions, with a perspective of improving the environment by containing pollution. At the end of my talk I will discuss on very recent investigations where the use of QENS has been extended to the study of the confinement of small pharmaceutical drugs into carriers. Here I will discuss on the intrinsic interest of the pharma-industry in the mechanisms of diffusive drug molecule exchange between carriers and their aqueous environment in the complex solutions present in cells of living organisms.

W. P. Gates, H. N. Bordallo et al, *Journal of Physical Chemistry C*, **116**, 5558-70 (2012)
H. N. Bordallo et al, Eur. Phys. *J. Special Topics* **189**, 197-203 (2010)
H. N. Bordallo and L.P. Aldridge, *Zeitschrift für Physikalische Chemie*, **224**, 183-200 (2009)
H. N. Bordallo et al, *ACS Appl. Mater. Interfaces*, **1**, 2154-62 (2009)
H. N. Bordallo et al, *Journal of Physical Chemistry C*, **112**, 19982-91 (2008)
H. N. Bordallo et al, *Journal of Physical Chemistry B* **110**, 17966-76 (2006)
L.P. Aldridge , H. N. Bordallo and A. Desmedt, *Physica B* **350**, e-565-8 (2004)

Heloisa Bordallo

Françoise Brochard-Wyart, Olivier Sandre, Erdem Karatekin, Nicolas Borghi, David Gonzalez, Elyes Mabrouk, Min-Hui li, Damien Cuvelier and Pierre Nassoy

Dynamics of membrane pores

The opening and closure of pores in cells and vesicles is of great biological relevance for the transport of ions, molecules and pathogens, and is also involved in cell-vesicle fusion.
We describe pore dynamics in three systems
I)Transient pores in vesicles induced by membrane stretching
If the membrane tension is increased, the vesicle respond by a sudden and rapid opening of pore which relaxes the tension, followed by a closure of the pore . We discuss the dynamics of pore opening and closing, and the pore maximal size. We show that certain detergents "wedge-actants" reduce the line tension, increasing the pore life time This work opens perspectives in trans membrane transport, endocytosis and exocytosis
II) Pores in polymersomes induced by membrane spontaneous curvature .
We describe a new mechanism of bursting of asymmetrical membranes ,induced by spontaneous curvature. The pore is surrounded by a curled rim
III) Macro-apertures in intoxicated cell. We describe the holes in epithelial cells
infected by EDIN, a toxin which allow the staphylococcus aureus to traverse the epithelial barrier, which have common features with transient pores and liquid dewetting

Françoise Brochard-Wyart

Yves Couder[1] and Emmanuel Fort[2]

[1]Matières et Systèmes Complexes,Université Paris 7 Denis Diderot, CNRS - UMR 7057, Bâtiment Condorcet, 10 rue Alice Domon et Léonie Duquet, 75205 Paris, cedex 13, France
[2]Institut Langevin, ESPCI ParisTech and Université Paris Diderot, CNRS UMR 7587, 10 Rue Vauquelin, 75 231 Paris Cedex 05, France

A "double solution" in the classical wave-particle duality of walkers

A "walker" is formed of the association of a bouncing droplet with a surface wave it generates. Several experiments have demonstrated that this structure has some of the properties of a genuine wave-particle duality. I will present some new experimental situations where this characteristic is confirmed. During the second part of the talk I will show that these results can be described in terms of a double wave structure, one wave being the real surface wave driving the motion of an individual drop, while the other is a probability wave that characterizes the statistical behaviors. For this reason our experiment appears to have the main characteristic hypothesized by de Broglie in his "double solution" for quantum mechanics. An interesting feature is that, in our experiments, the link between the individual behavior and the probabilistic one is observed. It is related to a form of chaos due to the wave-mediated path-memory that characterizes our system.

Yves Couder

Julien Delahaye[1], T. Grenet[1] and M.C. Cheynet[2]

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Electrical glassy behaviour in granular aluminium thin films

Insulating granular aluminium films are disordered systems made of nanometric aluminium grains embedded in an alumina matrix. They have received a renewed interest recently because they display slow relaxations of the electrical conductance at low temperature. For example, after a quench in liquid helium, the conductance is seen to decrease as a logarithm of time without any sign of saturation after weeks of measurement [1]. Two models have been proposed in order to explain these slow relaxation phenomena. According to the first one, they result from a glassy state of the electrons induced by disorder and long range electron-electron interactions, the so called "electron glass". In an alternative explanation developed for granular systems, such effects could stem from a slow response of the dielectric material around the metallic grains.
In this presentation, we will first explain how our granular aluminium films are made and what their structure is. We will then outline some basic features about the electrical properties of insulating granular metals. And we will end with a description of the glassy behaviour observed at low temperature in our granular aluminium films. Our results will be compared with similar experiments done in other disordered insulators, in order to bring out arguments against and in favour of the two different models.

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Julien Delahaye

Paul Dommersnes[1]*, Knut Kjerstad [2], Kjetil Hersvik[2], Alexander Mikkelsen[2], Rene Castberg[3], Zbigniew Rozynek[2], Jon Otto Fossum[2*]

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2 Department of Physics, NTNU, Trondheim, Norway
3 Physics Department, University of Oslo, Norway
**Centre for Advanced Study, Norwegian Academy of Science and Letters, Oslo, Norway*

Clay-oil drops in electric fields

Electric field manipulation of droplets has many applications, for example in emulsion technology and microfluidics. The response of an isolated emulsion droplet depends both on the electric properties and viscosity of the two liquids. For perfect dielectrics the electric surface stress at the liquid interface induces prolate droplet deformation. In “leaky-dielectrics” the electric surface stress can induce hydrodynamic flow in and around the droplet and give oblate droplets (G.I. Taylor 1964).

Here we present experiments on isolated oil-in-oil emulsions droplets containing colloidal clay particles. The clay-oil droplet is an electro-rheological liquid where both electric properties and viscosity change dynamically in response to the applied electric field. The experimental observations are discussed within the framework of existing theories for electro-hydrodynamics and electro-rheology.

Paul Dommersnes

Antonio Martins Figueiredo Neto

Institute of Physics, University of São Paulo, Brazil

Mechano-optical properties of elastomers and ferroelastomers

Chemically cross-linked network swollen by magnetic nanoparticles are usually named a ferrogel. Magnetic-field gradients may promote elongation and contraction behavior on this material. This property might lead to many different applications, from soft actuators or micromanipulators in technical fields to applications in medicine, where they might act as artificial muscles or carriers for drugs. There are some different ways to produce ferrogels. One of them is the swollen of the elastomeric matrix and further incorporation of the nanoparticles. In previous works we show that Fe_3O_4 grains from magnetic colloids can be efficiently incorporated into the urethane/urea elastomer. The elastomers studied consist of two soft segments, polypropylene oxide and polybutadiene. Two kinds of cross-linked covalent nets are formed. One is originated by the reaction of PBDO (polybutadiene diol) hydroxyl end groups with PU (polypropylene) oxide based isocyanate terminated triol prepolymer (isocyanate) groups, promoting the urethane linkage. Another one occurs when there is an excess of isocyanate groups with respect to the hydroxyl groups. The reaction of the nonreacted isocyanate end groups with atmospheric moisture originates the formation of urea linkages. The number of urea/urethane linkages can be controlled as a function of the PU/PBDO ratio. As the amount of PBDO increases, the urea linkages decrease and the cross-linking degree decreases. In this talk we report on some mechano-optical properties of urethane/urea elastomers **(**PU/PBDO), based on polypropylene oxide and polybutadiene diol, pure and doped with ferrofluid. The ratios in *wt%* of PU and PBDO investigated are 40/60, 50/50, 60/40, and 80/20. We showed that the incorporation of nanoparticles in the elastomeric matrices strongly depends upon the ratio of PU/PBDO. This fact seems to correspond to the different degrees of cross-linking. Ferrofluid particles were efficiently incorporated into the matrices of PU/PBDO elastomers by swelling the samples in toluene and ferrofluid solutions. We observed an optimal swelling time t_o to incorporate the largest amount of nanoparticles in the elastomers. This characteristic time depends on the PU/PBDO relative concentrations. The balance between urethane/urea links seems to be critical for incorporation of nanoparticles into the polymer network. A larger amount of PU, with higher cross-link density, allows a lower diffusion of the nanoparticles. A larger amount of PBDO implies lower density of cross-links and the matrix seems to retain less nanoparticles. The orientation of the optic axis and its dependence on the relative stretching was shown to be dependent on the casting direction with respect to the stretching direction in undoped samples. On the other hand, in doped samples this anisotropy was not observed. The presence of nanograins in the elastomeric matrix, which act like impurities, seems to account for this behavior. Some of the potential applications of ferrogels are particularly affected by our results. One of them is the use of ferrogels as birefringent materials. In this case, our results indicate that samples with PU/PBDO=50/50 and 40/60 are the more efficient to incorporate nanoparticles, and these nanoparticles increase the birefringence with respect to the pure sample.
Some refs.: 1) Brazilian Journal of Physics **35**, 184 (2005); 2) Journal of Applied Physics **102**, 073524 (2007). *People involved in this work*: Dr. C. Sena, Profa. Dra. M.H. Godinho, Dr. J.L. Figueirinhas and Prof. Dr. P. Palffy-Muhoray. *Acknowledgements*:Brazil {CNPq, FAPESP, INCT-FCx}, Portugal {POCI/CTM/56382/2004-FEDER, FCT**,** CENIMAT}

Antonio Martins Figueiredo Neto

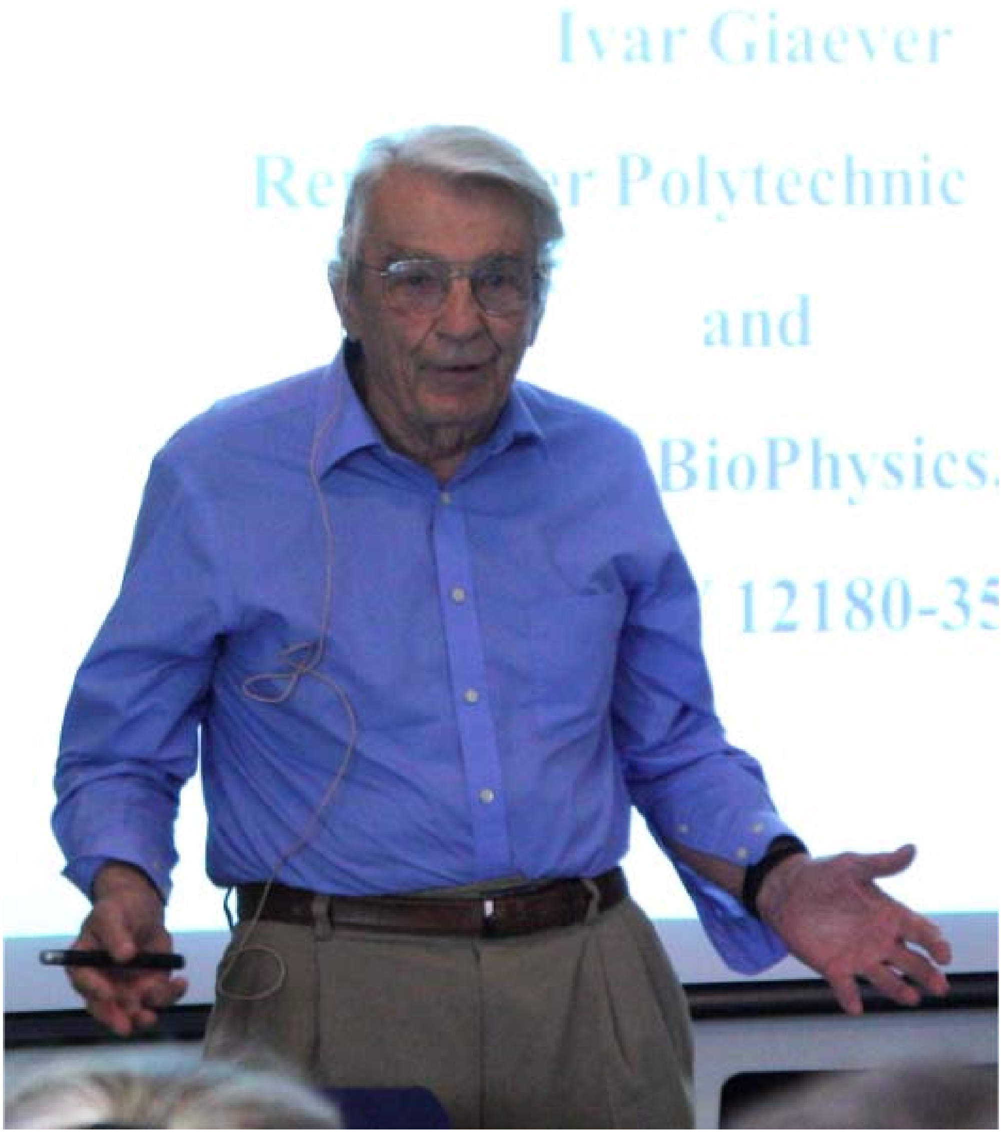
Aldo Jesorka

Ivar Giaever

Applied BioPhysics, Inc. Troy NY 12180

Nanotechnology, Biology and Business

Nanotechnology has received a lot of attention lately and it holds much future promise to make things both cheaper and better. In this talk I will describe some of my attempts in this field. In particular I will talk about a general immunology detector that utilizes small indium particles to detect antibodies. I will also describe a whole cell bio-sensor using electrical fields to obtain information about the morphology of cells in tissue culture. Finally I will touch on how to bring nanotechnology to the market.



Ivar Giaever

Aldo Jesorka

Department of Chemical and Biological Engineering, Chalmers University of Technology, Kemivägen 10, SE-412 96 Göteborg, Sweden

A Multi-Purpose Microfluidic Pipette for Localized Superfusion

Microfluidics has opened a multitude of possibilities for the control of chemical environments at small length scales, enabling functionality and precision which were previously unattainable. Creating solution environments locally is of a great interest for research problems where it is desirable to chemically manipulate micro-scale objects in a fluid environment, such as phospholipid membrane patches on a solid support, or single cells within a tissue slice. Recently, several new concepts to deliver small amounts of liquid to surface-adhered objects of interest have been reported. Examples include the chemistrode [1], and the vertical microfluidic probe [2].

We have developed a multifunctional microfluidic pipette (Fig. 1) featuring a circulating liquid tip that generates a self-confining volume in front of its outlet channels [3]. This device, fabricated by soft lithography in poly(dimethylsiloxane) (Fig. 1A), or alternatively by a multi-layer process we developed for expoxy photoresist (Fig. 1B), enables contamination-free chemical stimulation of targeted microscopic objects. Hydrodynamic confinement separates the fluid in the rotating tip efficiently from the bulk liquid (Fig. 1C). The pipette is capable of carrying out a variety of fluid processing functionalities, such as mixing, multiplexing, or gradient generation. On-chip wells ensure low sample consumption and convenient use. Electrodes can be integrated for additional functionality, *e.g.*, electroporation or impedance spectroscopy. The self-confined liquid tip is flexible and scalable as the geometry and the size of the recirculation zone is defined by pressure, channel number, and geometry.

Selected application examples [3]*:* The determination of the effective calcium concentration for lipid membrane spreading on silica, single cell dose-response measurements on drugs acting on ion channels, and local generation of calcium waves in cell networks are a few examples of recent uses of the technology.

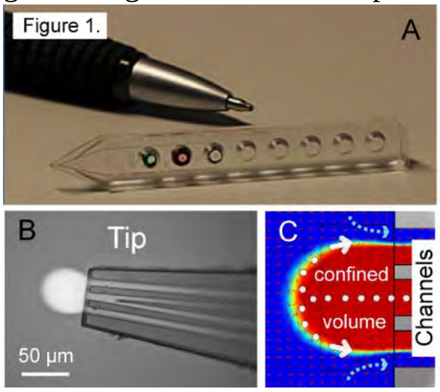


Figure 1. A) Image of the microfluidic pipette in PDMS with device-integrated wells). B) Brightfield/fluorescence micrographs (overlay) of an epoxy-photoresist device tip in a droplet of buffer, visualizing the hydrodynamically confined liquid tip by means of a fluorescein solution. C) Concentration gradient map for fluid recirculation within an open volume (red highest, blue lowest concentration) obtained by a FEM simulation.

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Mogens Høegh Jensen

Niels Bohr Institute, Copenhagen, Denmark

Modeling Plankton in Turbulence

Satellite pictures indicate that plankton in the oceans exhibit 'foliated' structures on many length scales clearly influenced by the turbulent flows in the water. We have formulated a particle model where plankton are advected in strong turbulence model field [1,2]. We observe a huge drop in the carrying capacity due high concentrations in the stagnation points of the flow. For two neutral alleles, we find that turbulence diminishes the fixation time significantly. We furthermore study the fixation time as a function of various flow parameters. We obtain analytical expressions for the fixation probability without flows [2]. From simulations of the model in zero and one dimensions we find good agreement with theoretical predictions both when species experience competitive exclusions and when they co-exist under mutualistic behavior [2].

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Mogens Høegh Jensen

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Time-resolved Synchrotron SAXS Study of Micelle Formation

Self-assembly of amphiphilic molecules into micelles occurs on very short times scales of typically some milliseconds and is therefore very hard to observe experimentally with structural resolution. Whereas rate constants of surfactant micelle kinetics have been accessed by spectroscopic techniques for decades, so far no experiments providing detailed information on the structural evolution of surfactant micelles during their formation process have been reported. In this work we show that by applying synchrotron radiation small-angle X-ray scattering (SAXS) in combination with the stopped-flow mixing technique, the entire micellization process from single surfactants to equilibrium micelles can be followed *in situ*. Using a novel surfactant system of dodecyl maltoside in dimethylformamide (DMF), micellization can be induced simply by adding water, and can then be followed *in situ* by SAXS. Mixing of water and DMF is an exothermic process. Thus, the micellization process occurs under non-isothermal conditions with a temperature gradient relaxing from about 40 to 20 ºC. A mechanistic nucleation & growth model describing micelle formation by insertion/expulsion of single molecules under non-isothermal conditions was developed and found to describe the data surprisingly well.

Grethe Vestergaard Jensen

Tom Henning Johansen

Department of Physics, University of Oslo, Norway, and
Centre for Advanced Study at the Norwegian Academy of Science and Letters, Oslo

Particle manipulation using mobile magnetic domain walls

Magnetic domains in ferromagnetic films are generally producing localized stray magnetic fields on the surface. If the domain boundaries, the magnetic walls, are mobile, one has in principle a method for micro-manipulation of magnetic particles placed on the film. Ferrite garnet films are particularly suited for this purpose, because their domains can form regular structures, such as parallel stripes and a hexagonal lattice of circular bubbles. In this talk I will describe the method and how we successfully have used it in a number of ways to manipulate different particles such as micronsized superparamagnetic beads and magnetotactic bacteria, and even superconducting vortices. The bead manipulation is of particular interest since beads of polystyrene can carry biomolecular cargo, e.g., DNA and cell fragments on their surface, and thus the method represents a novel route towards biomolecular Lab-on-a-Chip design and molecular computing.

Tom Henning Johansen

Ruben Juanes

MIT, Cambridge – MA, USA

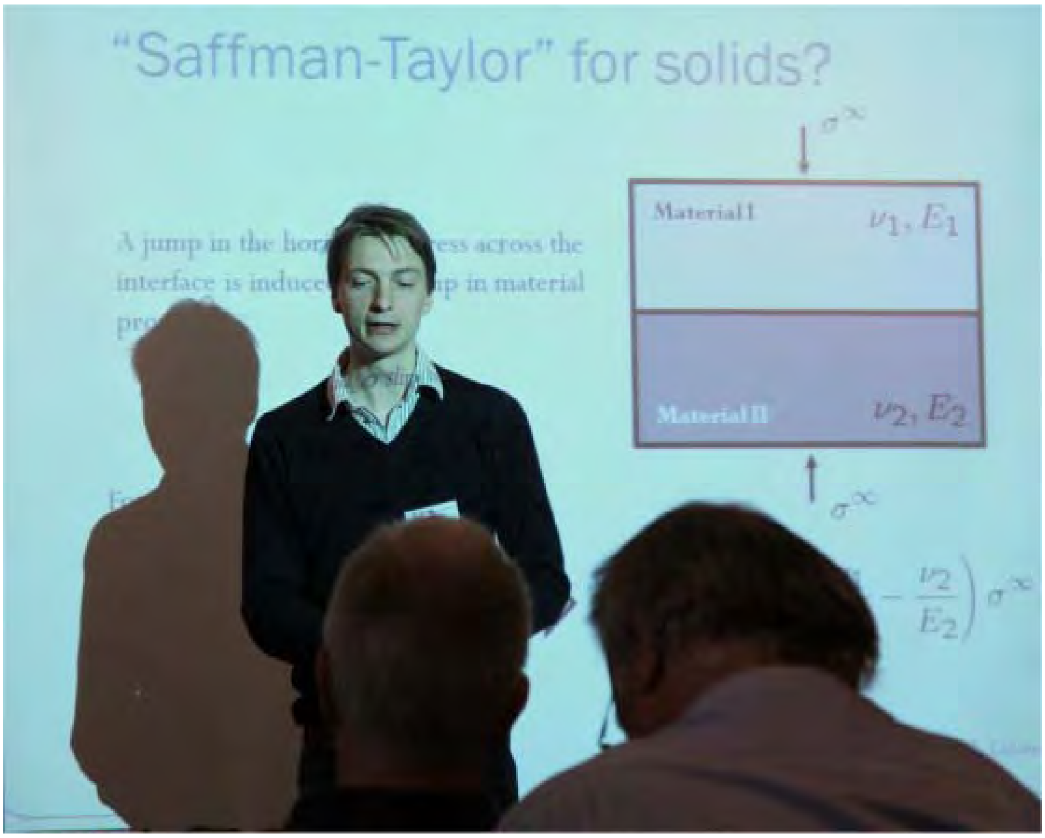
Fingering and fracturing in granular media

In this talk, I will cover two recent results.

The first is a *macroscopic phase-field model of partial wetting* that permits describing the statics and dynamics of two-phase flow in a capillary tube. Drops and bubbles are non-spreading, local, compactly supported features. They are also equilibrium configurations in partial wetting phenomena. Yet, current macroscopic theories of capillary-dominated flow are unable to describe these systems. We propose a framework to model multiphase flow in porous media with non-spreading equilibrium configurations. We illustrate our approach with a one-dimensional model of two-phase flow in a capillary tube. Our model allows for the presence of *compactons*: non-spreading steady-state solutions in the absence of external forces. We show that local rate-dependency is not needed to explain globally rate-dependent displacement patterns, and we interpret dynamic wetting transitions as the route from equilibrium, capillary-dominated configurations, towards viscous-dominated flow. Mathematically, these transitions are possible due to non-classical shock solutions and the role of bistability and higher-order terms in our model.

The second is the phenomenon of *capillary fracturing in granular media*. We study the displacement of immiscible fluids in deformable, non-cohesive granular media. Experimentally, we inject air into a thin bed of water-saturated glass beads and observe the invasion morphology. The control parameters are the injection rate, the bead size, and the confining stress. We identify three invasion regimes: capillary fingering, viscous fingering, and "capillary fracturing", where capillary forces overcome frictional resistance and induce the opening of conduits. We derive two dimensionless numbers that govern the transition among the different regimes: a modified capillary number and a fracturing number. The experiments and analysis predict the emergence of fracturing in fine-grained media under low confining stress, a phenomenon that likely plays a fundamental role in many natural processes such as primary oil migration, methane venting from lake sediments, and the formation of desiccation cracks.

Ruben Juanes



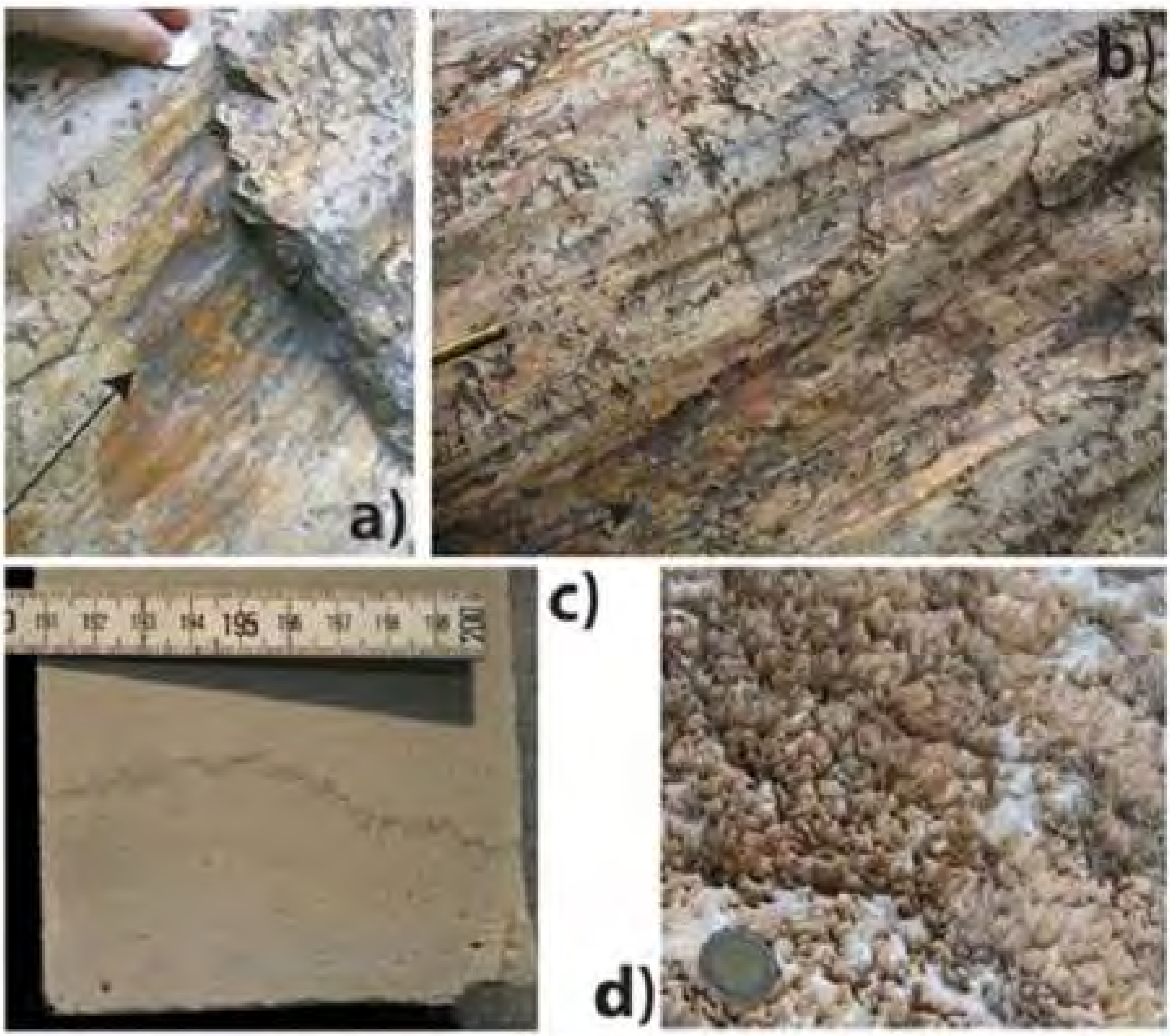
Joachim Mathiesen

Joachim Mathiesen

Niels Bohr Institute, Copenhagen, Denmark

Pattern formation in stressed multi-phase systems

Fluid flow is responsible for a host of remarkable patterns and surface shapes on Earth. Fluid flow controls the rate of basic geological processes such as rock compaction and the frictional healing of faults. Here we consider reactive transport by fluids in stressed porous materials. We discuss morphological instabilities at solid-fluid interfaces and solid-solid interfaces. Localized compaction/precipitation patterns and even fracture networks may spontaneously form from material dissolution in regions of high stress, diffusion through the fluid-saturated pore space and precipitation in regions of low stress. We present conditions for the stability of a stressed interface in terms of external loading conditions and material properties and discuss the possible consequences for the roughness of faults surfaces and grain boundaries.



Paul Meakin[1,2,3,4], Anders Nermoen[1], Simon D. deVilliers[1], Stephanie C. Werner[1], Joachim Mathiesen[1,5], Dag K. Dysthe[1], Christophe Raufaste[1], Espen Jettestuen[1] and Bjorn Jamtveit[1]

1. Norwegian Center of Excellence for the Physics of Geological Processes
2. Idaho National Laboratory, Carbon Resource Management Department
3. Institute for Energy Technology, Kjeller
4. Temple University, Department of Physics
5. Niels Bohr Institute, University of Copenhagen

Pattern formation in granular materials: Martian "spiders" and partially fluidized bimodal mixtures

A wide range of geometrically and dynamically complex patterns are produced by the interactions between flowing fluids and unconsolidated granular media. We focus on two examples:
1. the formation of branched channels by the erosion of a granular bed in a horizontal Hele-Shaw cell; and
2. columnar size segregation in a vertical Hele-Shaw cell filled with a mixture of large and small particles.
The branched channels resemble the "spiders" or "araneiforms" formed under subliming sheets of CO_2 ice at high southern latitudes during the Martian Spring, and the experimental system provides a physical model for the important erosion process that generates Martian araneiforms. The columnar size segregation morphology investigated in the vertical Hele-Shaw cells may be relevant to fluidized granular systems on Earth. The fundamental processes that control these intriguing pattern formation phenomena will be discussed.

Paul Meakin

Yves Meheust(1), J.-R. de Dreuzy(2,1) and G. Pichot(1,3)

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(2) Institute of Environmental Analysis and Water Studies, CSIC, Barcelone (Spain)
(3) IRISA/INRIA, Université Rennes 1, Rennes (France)

Flow in fractured geological media: the influence of fracture scale heterogeneity

Flow channeling and permeability scaling in fractured geological media have been until now adressed either at the fracture- or at the network- scales. In the latter case they are linked to the topological structure of the network, while at the fracture scale they are controlled by the variability of the local aperture distribution inside individual fractures. We combine these two effects and investigate how flow localization below the scale of individual fractures impacts that at the network scale and the resulting medium permeability. This is addressed with a highly-resolved 3D discrete fracture network model that accounts both for the typical topology of geological fracture networks and for the spatially-correlated roughness of fracture walls.

Yves Meheust

M. Motta, F. Colauto[1], J. I. Vestgaarden[2], J. Cuppens, V. V. Moshchalkov, A. V. Silhanek, R. B. Dinner, M. G. Blamire, T. H. Johansen[2*], **W. A. Ortiz**[1*]

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[2] Department of Physics, University of Oslo, Oslo, Norway.
**Centre for Advanced Study at the Norwegian Academy of Science and Letters, Oslo*

Morphology of flux avalanches in superconducting films

Under certain conditions of temperature and magnetic field, sudden flux bursts develop into superconducting films, as a consequence of thermomagnetic instabilities, which occur when heat dispersion is slower than magnetic diffusion. We have employed magneto-optical imaging to visualize the occurrence of flux avalanches in superconducting films of Nb and a-MoGe. Some of the specimens were pristine films, whereas some others were decorated with antidots (ADs) arranged in a square lattice. The shape of the ADs varied from sample to sample, from square, to circular, to triangular. All samples were thoroughly characterized by measurements of ac susceptibility and dc magnetization, carried out in commercial Quantum Design equipment (MPMS and PPMS). For the pristine samples, the typical format of bushes is observed. Films with lattices of ADs, however, exhibit avalanches guided by the arrangement of defects, with a morphology that is strongly dependent on the shape of the holes.
To model the problem one has to take into account the Joule heating created by vortex motion, the reduction of the critical current density as the temperature increases, and also the nonlinear material characteristics of type-II superconductors, which are major actors leading to the appearance and evolution of the instability process. A model consistent with these facts has been developed and implemented. Numerical simulations were performed, confirming the overall features of the avalanches.

Wilson Ortiz

A. L. Washington[1], X. Li[1], A. B. Schofield[2], K. Hong[3], and **Roger Pynn**[1,4,*]

[1]Center for Exploration of Energy and Matter, Indiana University, Bloomington, IN 47408, USA, [2]School of Physics and Astronomy, University of Edinburgh, Edinburgh, EH9 3JZ, Scotland, [3]Center for Nanophase Materials Science, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA, [4]Neutron Sciences Directorate, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA,
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Probing Depletion-Induced Correlations in a Colloidal Fluid

Correlations between ~ 250-nm-diameter, surfactant-stabilized, monodisperse poly(methyl methacrylate) (PMMA) spheres have been measured in concentrated suspensions using a new neutron scattering technique called Spin Echo Small Angle Neutron Scattering (SESANS). This method directly yields a projection of the Debye correlation function over distances between ~50 nm and several microns. It is a more sensitive measure of correlations than conventional Small Angle Neutron Scattering (SANS). The refractive indices of the PMMA spheres and the carrier fluid (decalin) were approximately matched, suppressing Van der Waals attractions between the spheres. For PMMA volume fractions up to 40%, the Percus-Yevick hard-sphere approximation gave a good description of the data, whereas for 50% volume fraction, significant departure from this theory was observed. A small concentration of molecular polystyrene (PS) added to the suspension caused controllable depletion-induced attraction between the spheres when the carrier fluid was a good solvent for PS. At sufficiently low concentration of PS (0.2 % by weight), the depletion interaction caused enhanced short-range correlations between spheres but little other change in the correlation function. The observed correlation function in this case was very similar to that predicted by calculations based on integral-equation theory for "sticky" hard spheres. For slightly higher concentrations of PS (0.5 % by weight), the correlations between PMMA spheres became fractal in nature with a dimension d_f = 2.6. Aggregate sizes up to 18 microns have been probed using SESANS. Optical microscopy has confirmed the existence of a lacunar structure in the fluid.

Roger Pynn

Adrian Rennie

Adrian Rennie

Materials Physics, Uppsala University, Uppsala, Sweden

Self-assembly and Order of Colloidal Particles at Interfaces and under Flow

Exploiting the ability of colloidal materials to self-assemble or to form order structures is a major challenge in nanoscience and nanotechnology. Although naturally occurring systems in biology have evolved to provide a hierarchy of structure at different length scales and useful three-dimensional order, it is more difficult with synthetic materials to provide similar reproducible specific interactions to drive structure formation. Some progress is made by use of chemical interactions of surfactants and ligands but application of mechanical stress or other fields such as magnetic or electric polarisation can also be valuable. Even the simple presence of a 'hard' planar boundary can direct orientation and structure of particles or promote 'prewetting' of a surfactant phase[1]. Combinations of different forces are likely to be the most successful mimics of nature.

The talk will describe some recent results that describe processing of anisotropic colloidal particles under the influence of elongational and shear flow.[2] Much lower strain rates but using the combined influence of both an air/liquid and a solid/liquid interface have allowed large areas of highly ordered structures of spherical particles (350 Å radius) to be obtained[3] as shown in Figure 1.

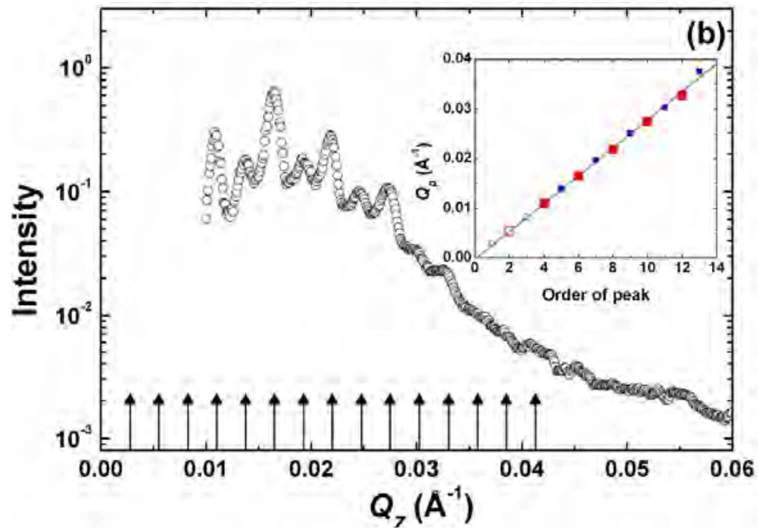

Figure 1. Diffraction peaks from ordered layers of polystyrene latex (sample area about 20 cm^2). Open symbols indicate peaks outside the measurement range. Arrows show the peak positions plotted in the insert.

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Dan Rothman

Lorenz Center and Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology

Growth and Ramification of Stream Networks

The geometric complexity of dendritic river networks has been a source of fascination for centuries. Yet a comprehensive understanding of ramification---the mechanism of branching by which these networks grow---remains elusive. Progress requires quantitative theory and comparison with unambiguous observations. This talk reports advances made in both realms. Our observational work focuses on thousands of bifurcated streams growing in a 100-km^2 groundwater field. Our theory represents streams as a collection of paths growing and bifurcating in a harmonic field. We predict that streams incised by groundwater seepage branch at a characteristic angle of 2 pi / 5 = 72 degrees. Our measurements, on the other hand, yield a mean angle of 71.8 ± 0.8 degrees. The large-scale manifestation of this bifurcation angle appears to be the assembly of the network into approximately parallelogram-shaped motifs of all sizes, the ratio of whose sides is equal to the golden ratio. Collectively, these results suggest that the network geometry at all scales is determined by the external flow field rather than flow within the streams themselves.

Dan Rothman

Bjørnar Sandnes[1], Henning A. Knudsen[2], Knut Jørgen Måløy[2], Eirik G. Flekkøy[2] and Jon Alm Eriksen[2]

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[2] *Department of Physics, University of Oslo, Sem Sælandsvei 24, PO Box 1048 Blindern, 0316 Oslo, Norway*

Granular mixtures on a slope

Labyrinthine structures emerge when a gas displaces a granular mixture in a confined, horizontal cell. Such multiphase flows may influence the transport and fate of gaseous phases along fractures and channels in petroleum reservoirs and CO_2 storage sites. Not all fractures/channels happen to be horizontally oriented though. Here we investigate the effect of gravity on self-organization during slow drainage of granular mixtures in slightly sloping, quasi-2D channels. Frictional, capillary and hydrostatic pressures conspire to produce a changing landscape of morphologies as we vary the experimental conditions. The pattern formation dynamics is reproduced in numerical simulations, and we explain the morphology phase transitions in terms of the contending forces.

Bjørnar Sandnes

Stephane Santucci

Laboratoire de Physique, ENS-Lyon, CNRS, France

Crackling Noise during the failure of heterogeneous materials

We study the growth of the crack front along a weak heterogeneous plane of a Plexiglas block. Using both a high resolution fast camera, and microphones (Wide Band transducers), we show that the fracture front displays a complex, jerky dynamics also called “Crackling Noise”, governed by irregular avalanches with very large size and velocity fluctuations. In particular, those local velocities follow a fat tail distribution $P(v/\langle v \rangle) \propto (v/\langle v \rangle)^{-(\alpha+1)}$ with a power law exponent $1 + \alpha = 2.6 \pm 0.15$, which has a diverging variance. As a consequence, the global (i.e. spatially averaged) velocity fluctuations of the crack front during its propagation follow a non-Gaussian distribution. Using a generalized version of the central limit theorem, we can predict the shape of such distribution, so-called *Stable Distribution*, characterized by the scaling exponent α and an asymmetry parameter β.

Stephane Santucci

Ritva Serimaa

Department of Physics, University of Helsinki, Finland

Studies on the hierarchical structure of plant cell wall and biomometic natural polymer based composites

Many properties of plant fibres arise from the cell wall structure. Plant cell wall is Nature's nanocomposite of partially crystalline cellulose and amorphous hemicelluloses and lignin. In the cellulose biosynthesis very long and thin microfibrils with a diameter of 3 nm are formed. The microfibrils are partially crystalline and they act as a reinforcing component in the cell wall. Microfibrils are bound together with hemicelluloses, which are formed at the same time. Amorphous lignin is synthesized later and it acts as filler in the cell wall.

The interest in these natural polymers is increasing due to the demands of sustainable development and the extending scope of applications. Novel materials like nanocrystalline cellulose are especially interesting. Nanocellulose is formed of both microfibrils and their bundles. If the microfibril bundles are small enough, the material becomes transparent. Cellulose acts as a reinforcing nanocomponent also in natural polymer based films. In addition to cellulose also the amorphous polymers play an important role in determining the behavior of plant cell wall or natural polymer based films e.g. during drying.

Here results on studies of the structure and properties of plant cell wall and biomimetic films using various techniques based on x-rays are reviewed. Results are presented particularly of structural changes due to humidity or mechanical tension.

Ritva Serimaa

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Hydrodynamic analogies to electricity and magnetism: The fascinating life and scientific work of Carl A. Bjerknes

Carl Anton Bjerknes (1825-1903) was professor of mathematics in Christiania (now Oslo), from 1866 until his death. He is particularly known for his detection of hydrodynamic analogies to electricity and magnetism. He worked out the mathematics of pulsating spheres in a fluid, finding that they were the 'mirror image' of electric charges and magnetic poles in that 'like' spheres attracted each other and 'unlike' spheres repelled with forces varying as the inverse square of the distance between them.

Bjerknes had a fascinating life and career. In 1844 he entered the University of Christiania (now Oslo), where he studied mining. He was awarded a degree in mining engineering in 1848 and for the next four years he worked at the Kongsberg silver mines. The work consisted of making sure miners were not stealing the silver from the mines. It was during the long hours on duty that Bjerknes began to orient himself toward a scientific career. In 1852 he received a gold medal in mathematics giving him a chance to travel abroad to hear lectures by Dirichlet and Riemann in Göttingen and Cauchy in Paris.

Bjerknes tried to explain the electrodynamics of Maxwell by hydrodynamic analogies and similarly he proposed a mechanical explanation of gravitation. Although he didn't succeed in his attempts to explain all those things, his findings in the field of hydrodynamics were important. His experiments were shown at the electric exhibition in Paris in 1879 where he received an honorary diploma along with celebrities such as Edison, Bell, Siemens and Thomson.

Some published works by C.A. Bjerknes:
Om de indre tilstande i et inkompressibelt ubegrændset fluidum, hvori en kugle bevæger sig, idet den forandrer volum, VSK Forh. 1863, p. 13–42
Sur les mouvements simultanés de corps sphériques variables dans un fluide indéfini et incompressible. 1. mémoire, VSK Forh. 1871, p. 327–402
Hydrodynamiske Analogier til de statisk elektriske og de magnetiske Kræfter, Naturen 1880, p. 49–59 and 81–91

Arne Skjeltorp

Niclas Solin, F. G. Bäcklund and O. Inganäs

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Preparation of Functionalized Amyloid-like Materials

When heated in acid many proteins will self-assemble into wire-like structures known as amyloid fibrils. The protein wires typically have diameters of about 10 nm and lengths in the μm range. Moreover, there is often concomitant formation of structurally related spherically shaped amyloid materials with a typical diameter of 50-100 μm. In this lecture we will focus on the self-assembly of the small protein insulin into such amyloid materials. We have developed methods to functionalize such insulin-based amyloid materials with e.g. luminescent organic molecules and magnetic nanoparticles. Moreover, we have found that hydrophobic molecules may have dramatic effects on the self-assembly process, resulting in novel protein-based structures.
In this lecture we will discuss the preparation and application of such functionalized structures.

Niclas Solin

Tuomas Tallinen

Harvard University, Cambridge – MA, USA
Univ. Jyväskylä. Finland

Compression driven pattern formation in soft solids

Constrained growth or swelling of soft elastic solids, such as biological tissues and gels, can generate large compressive stresses at their surfaces. A smooth surface of such a solid becomes instable when its compressive stress exceeds a critical value. This leads to complex three-dimensional sulcus morphology in systems where the stress is biaxial. Recent theoretical and numerical studies have unfolded the nonlinear nature of sulcification instability, but open questions still remain on symmetries, geometry and energetics of sulcification patterns. We are now addressing these questions by large scale simulations of biaxially compressed elastic layers. We highlight the role of sulcification in mechanical pattern formation in tissues and discuss possible ways to utilize sulcification for functional patterning of soft solids.

Tuomas Tallinen

Renaud Toussaint (1,2,3), Knut Jørgen Måløy (3,2,1),
Eve-Agnès Fiorentino(1), Gerhard Schafer (4), Mihailo Jankov (3)

(1): Institut de Physique du Globe de Strasbourg, University of Strasbourg/CNRS
(2): Center for Advanced Studies
(3): AMKS, Complex, University of Oslo
(4): LHYGES, University of Strasbourg/CNRS

Capillary pressure / saturation relationships in a diphasic flow in a random medium: Influence of the boundary conditions

Solving problems involving biphasic flows in porous media, at a scale larger than the pore one, normally requires the use of relationships between pressure and saturation. These allow the closure of generalized Darcy flow models for two phases, commonly used in hydrology or large scale problems of diphasic flow in porous media.
There are mathematical models which approximate experimental records with curve-fitting equations. The two most common models are the Brooks-Corey and van Genüchten ones, they are used to complete a system of generalized Darcy equations.
The purpose is to study the influence of the boundary conditions on the relationship between pressure and saturation. We perform numerical simulations of drainage experiments. Water is the wetting fluid and air is the non wetting fluid. The results highlight the fact that a filter which allows only water to flow at the exit face of the system modifies both the shape of the curve and the value of the residual saturation. The pressure of the models that are commonly used does not match with the pressure of real flows since there is no filter to cross, to flow from an elementary volume to another.
Modeling flows in open media requires using the central part of the curves where the effect of the boundaries is the least important.

Renaud Toussaint

Giovani Vasconcelos

Departamento de Física,Universidade Federal de Pernambuco, Recife, PE, Brazil

Fingers and bubbles in a Hele-Shaw cell: Exact solutions and the selection problem

Pattern selection (far from equilibrium) was a long-standing challenge for theoretical physics since the late 1950s, when pioneering experiments on fingering in a Hele-Shaw cell were conducted by Sir G. I. Taylor and collaborators. The main difficulty in attacking the so-called selection problem was the absence of conventional mathematical tools to describe unstable interface dynamics. Significant progress was made in 1980s when several theoretical groups produced results on pattern selection by including an infinitesimal amount of surface tension, using an approximative technique called "asymptotic beyond all orders" (M. Kruskal and H. Segur, 1983). After that, other theoretical efforts were conducted to try to explain the selection mechanism without having to resort to surface tension effects (Mineev, 2000).
In this talk, I will first present a brief review of exact solution, both stationary and time-dependent, for fingers and bubbles in a Hele-Shaw cell. I will then move on to report a new class of time-dependent exact solutions, recently obtained in joint work with M. Mineev-Weinstein (NMC, Los Alamos, USA), for a single bubble in a Hele-Shaw channel without surface tension. It is shown that this class of solutions evolve in time towards a stationary shape corresponding to the Taylor-Saffman bubble with a selected velocity $U=2V$, where V is the far-field fluid velocity. The results are in a full agreement with experiments. These results were possible to obtain due to a remarkable and powerful integrable structure of the non-linear interface dynamics equations, which we will briefly discuss.

Giovani Vasconcelos

Jørn Inge Vestgården, Joakim Bergli, Tom Henning Johansen

Department of Physics, University of Oslo

Analysis of paramagnetic micro-bead ratchets: The saddle point approach

Paramagnetic micro-beads (Ugelstad spheres) can be manipulated by using uniaxial ferrite-garnet films with a stripe domain pattern. For example, with periodic driving of the applied magnetic field the beads will jump coherently from domain wall to domain wall, with exactly one period of the stripe domain pattern per period of the applied field. In-plane driving three times faster than out-of-plane driving gives a surprise: beads of different sizes go in opposite directions.

We explain this strange behaviour by the topological properties of the magnetic force F(x,t), where x is position and t is time. When varying the height of interaction z, we find that the topology changes when the saddle points of F cross zero, and we are consequently able to classify the topology by following the saddle points. From the topology we immediately get the net bead motion. The results are verified by numerical solution of the equations describing the overdamped dynamics of the beads.

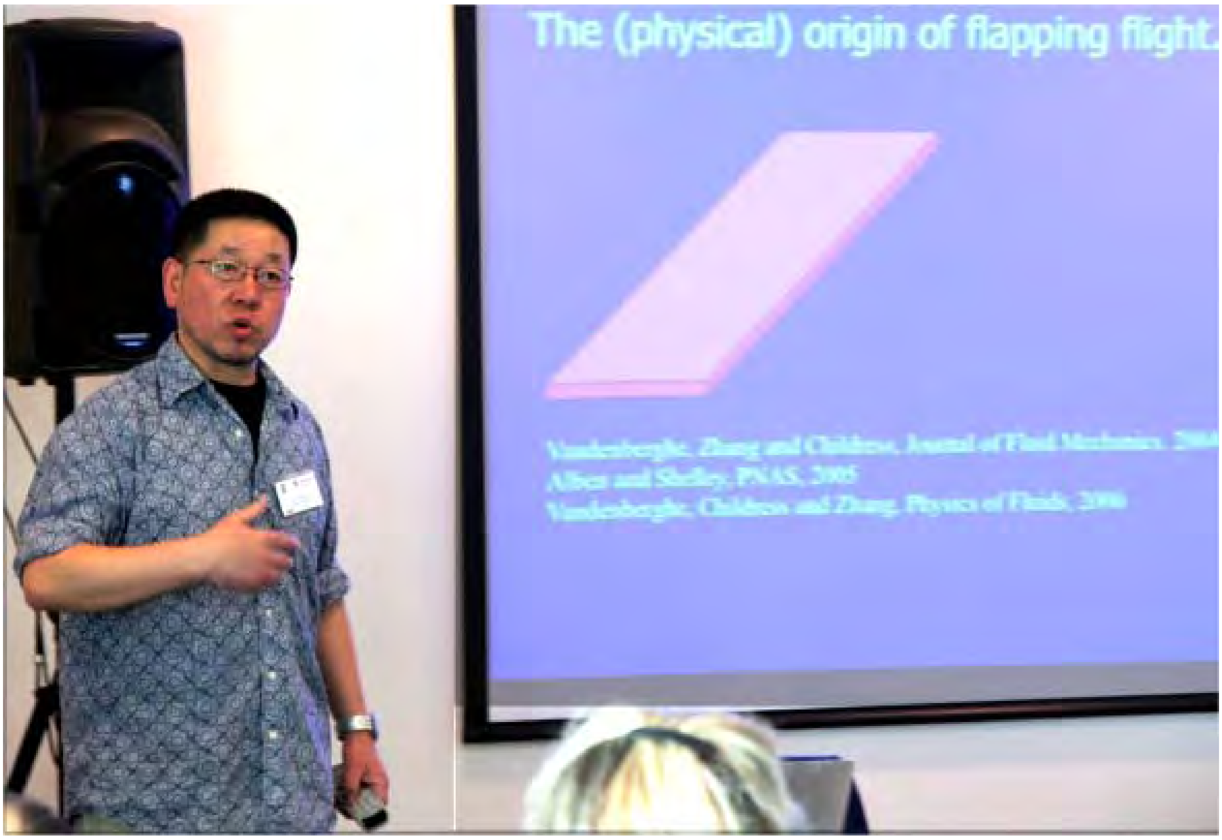
Jørn Inge Vestgården

Jun Zhang

New York University

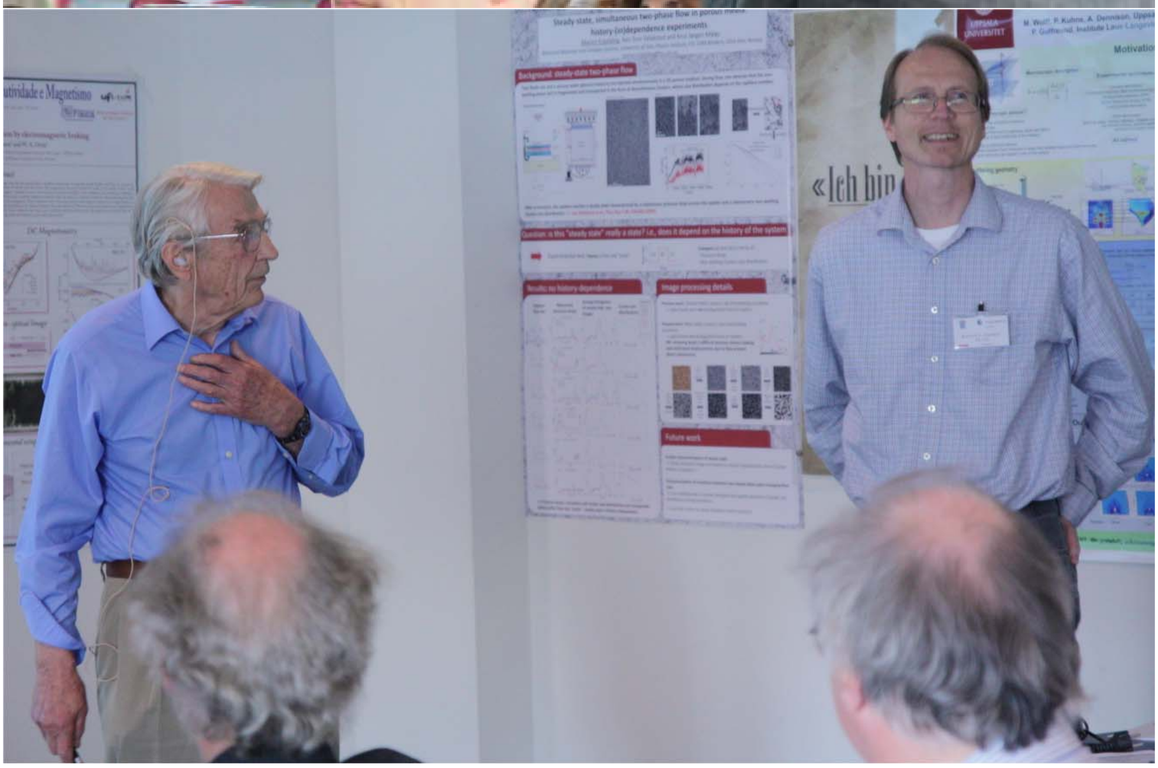
Fluid Ratchets and Biolocomotion

In this talk, I will discuss a few laboratory experiments where moving structures freely interact with the surrounding fluid. These moving structures, or boundaries, behave in asymmetric ways - either because of their anisotropic construction or by the spontaneous breaking of symmetry in their response to the fluid. When subjected to reciprocal forcing, their motion might be described as a ratcheting behavior. In one case, a fluid is forced through a corrugated channel that is under shaking. In another, a solid body hovers stably in an oscillatory airflow, mimicking a hovering insect. Lastly, a symmetric wing leaps into a forward flight when flapped up and down, following a symmetry breaking bifurcation.
These phenomena can be viewed as the starting points for understanding the effect of increasing biological realism.



Jun Zhang

There were some questions after each talk:



POSTERS

Paul Meakin and Ruben Juanes

Francoise Brochard and Paul Dommersnes

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Extreme value statistics in avalanches near depinning transition

At mesoscopic scales, plastic deformation of many crystalline materials happens by intermittent slips similar to earthquakes. These intermittent plastic slips are attributed to the collective dynamics of crystal defects, such as dislocations, due to their stick-slip type of motion. Experiments report a power-law distribution of the maximum amplitude of the acoustic emission (AE) during each slip avalanche and, so far, a theoretical prediction for this has been lacking.
Hereby, we present recent theoretical results on the statistics of rare events inside avalanches. We derive the distribution of maximum avalanche velocities from a mean field interface depinning model, and show that it follows a universal scaling form, with a scaling function that can be determined exactly at the critical point. Since mean-field avalanches are typical to a broad class of disordered systems with crackling noise, we expect a robust extreme value statistics of correlated velocity fluctuations in avalanches of fixed or arbitrary durations.

Luiza Angheluta receives 2nd place (the 1st runner up) poster award. To the right: The Poster Award Committee President Ivar Giaever (The other committee members were Torstein Jøssang and Heloisa Bordallo). **Award: Diploma + 30 grams of dried codfish**

Rene Castberg[1], Zbigniew Rozynek[2], Knut Jørgen Måløy[1]*, Jon Otto Fossum[2]*, Eirik Flekkøy[1]*, Paul Dommersnes[3]*

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Electric field alignment of polarized Clay particles

The synthetic clay Lithium Flourohectorite's (LiFH) response to an electric field when suspended in silicone oil was studied using two methods: WAXS, and optical imaging. WAXS experiments give us information on the distribution of particle orientation during chain formation, a process that can take up to a couple of minutes. Larger particles were made through sedimentation of a suspension of LiFH in water, and the sheets formed in this manner are cut into particles. These particles were filmed as they aligned in the electric field, a process that can take anywhere from a couple of seconds to a couple of minutes, and the data were later analysed using Matlab. From these results we see that the rate of rotation is scales with the field as E^2 and the viscosity of the oil.

Rene Castberg, Elisabeth Lindbo Hansen and Henrik Hemmen

Fabiano Colauto[1], T. H. Johansen[2], and W. A. Ortiz[1]

[1] *Departamento de Física, Universidade Federal de São Carlos, SP, Brazil.*
[2] *Department of Physics, University of Oslo, Oslo, Norway.*

Flux avalanches and its suppression by electromagnetic braking

If a type-II superconductor is cooled down in a zero applied field and subsequently an external field, larger than the first critical field, is applied, vortices enter through the sample borders until they are captured by pinning centers. As a consequence, the system achieves an inhomogeneous flux distribution, with a higher density of vortices near the border that progressively decreases toward the center of the sample. Under a small perturbation this self-organized state can lead to vortex avalanches that rush into the sample due to a thermomagnetic instability process. Such behavior is related essentially to the capability of the sample and substrate to assimilate heat generated by vortex motion, which suppresses flux pinning and facilitates further flux motion. This provides a positive feedback mechanism that can result in a thermal runaway. In superconducting thin films these events have been visualized by real-time Magneto-optical Imaging, which reveals dendritic paths of abrupt flux propagation. These avalanches have a biunivocal relation with jumps on isothermal dc magnetization [1]. By placing a metallic layer nearby the superconducting film, the vortex avalanches are suppressed partially or totally, depending on the distance between film and metal [2, 3]. We have shown that avalanches are suppressed due to electromagnetic braking, in which a magnetic drag force works against vortex movement promoting the stability. Vortex avalanches are always very harmful for electronic devices and other applications, however, they can be avoided by covering films with a metallic layer, hence, bringing the materials to recover their capabilities of screening fields and transport superconducting currents.

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[2] M. Baziljevich *et al*. Physica C 369, 93 (2002).
[3] F. Colauto et *al*. Appl. Phys. Lett. 96, 092512 (2010)

<u>Marion Erpelding</u>, Ken Tore Tallakstad, and Knut Jørgen Måløy

Advanced Materials and Complex Systems group, University of Oslo, Norway.

Steady-state, simultaneous two-phase flow in porous media: History-(in)dependence experiments.

On the macroscopic scale, the flow of immiscible fluids in a porous medium is characterized by relating flow rate, pressure gradient across the system and saturation. At the pore scale, flow is governed by the competition between capillary and viscous forces. 2-dimensional porous media have been used by several groups over the past decades to obtain experimental insight about the link between these two levels of description. In particular, transient invasion phenomena arising when one of the phases is displaced by the other (capillary and viscous fingering) have been largely investigated. Here, following the work of Tallakstad *et al.*, we focus on steady-state, simultaneous 2-phase flow: in this case, both phases were injected *simultaneously* in a 2D porous medium with the same constant flow rate. As the two fluids invaded the system, one observed that the non-wetting phase was fragmented and transported in the form of discontinuous clusters of various sizes. After a transient, the system reached a steady-state characterized by a pressure drop across the system fluctuating around a constant average value, and a stationary size distribution of the air clusters. In the present work, we experimentally investigate the following problem: is this "steady state" a state in the thermodynamical sense, *i.e.*, does it depend on the history of the system?
To answer this question, we have performed experiments in which the flow rate is modified twice according to the following procedure: first, the porous cell is filled with the wetting phase (a water-glycerol solution) only. Then, both phases (water-glycerol and air) are injected simultaneously at a fixed flow rate Q1 and we wait until steady state is reached (steady state 1). After some time, we abruptly change the flow rate to a different value Q2 and wait until a new steady state is obtained (steady state 2). Finally, we change the flow rate back to its initial value and let the system relax to steady state (steady state 3). We compare steady states 1 and 3 using two criteria: the average pressure drop across the system, and the size distribution of the air clusters. We have tested different couples of flow rates giving different magnitudes and sign for the flow rate difference Q1-Q2. In all cases, we find that the pressure drop across the system within steady state 3 is clearly similar to that in steady state 1. Furthermore, within the precision of our technique, we find that the cluster size distributions in steady-states 1 and 3 are also similar, thus demonstrating the absence of history-dependence effects.

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Repair of large area pores in solid supported double bilayers

We show the closure of large area pores (~10-150 μm), on solid-supported flat giant unilamellar phospholipid vesicles (FGUVs) by chelating the Ca^{2+} ions which stabilize the pores. Removal of Ca^{2+}, starting from the pore edges, causes de-pinning of the distal (upper) from the proximal (lower) bilayer. This leads to shrinkage and eventually closure of the pores, which we show is driven by the pore edge tension. We found evidence that the repair mechanism depends on the site of pore nucleation and fate of propagation. For the pores which open close to the periphery of the vesicle, the flow of lipids to the pore region occurs directly from the multilamellar vesicle (MLV) across the distal membrane. The pores which encircle the multilamellar lipid reservoir are closed by the migration of lipids from the lower to the upper membrane via the edge of the spreading patch. The new findings suggest that stable pore formation and re-sealing of large area pores are dependent on binding interactions with the sub-membrane layer, in our case mediated by calcium ions, which is reminiscent of cytoskeleton-mediated cell membrane healing.

Inkeri Kontro and Ritva Serimaa

Henrik Hemmen*[,†], Erlend G. Rolseth[†] Karin Rustenberg[†], Davi M. Fonseca[†,‖] , Elisabeth L. Hansen[†] , Jon Otto Fossum*[,†,‡] , and Tomás S. Plivelic.[§]

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Carbon dioxide intercalation in a clay at near-ambient conditions

Due to current awareness of global warming and the challenges related to carbon capture and sequestration, interactions between clays and CO_2 are attracting attention in the scientific community. A recent molecular dynamics study by Cygan et al.[1] shows the possibility of intercalation and retention of CO_2 in smectites at 37 ^{o}C and 200 bar. This has led the authors to suggest that clay minerals may prove suitable for carbon capture and carbon dioxide sequestration.
In this work we add to the so far scarce experimental results in this field, by showing from x-ray diffraction measurements that gaseous CO_2 intercalates into the interlayer space of the synthetic smectite clay fluorohectorite at conditions close to ambient. The mean interlayer repetition distance when CO_2 is intercalated in Na-fluorohectorite is found to be 12.5 Å at -20 °C and 15 bar. The magnitude of the expansion upon intercalation is indistinguishable from that observed in the dehydrated-monohydrated transition for H_2O, but the possibility of water intercalation is ruled out by a careful analysis of the experimental conditions, and by repeating the measurements exposing the clay to nitrogen gas. The dynamics of the process is observed to be dependent on the pressure, with higher intercalation rate at increased pressure. Interestingly, preliminary measurements on Li-fluorohectorite indicate that the clay is able to retain the CO_2 in dry conditions at room temperature, witch hints at possible applications for storage.
The conditions studied are different from most of the simulations in the literature related to geological storage, but demonstrating intercalation at less extreme conditions could prove useful in understanding the processes involved. By avoiding extreme conditions, experimental verification of theory and simulations should become much easier, and the low pressures involved here enable the use of Kapton windows on the sample cell, thus allowing investigations with laboratory x-ray equipment instead of synchrotron sources.

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Inkeri Kontro[1], P. Jääskeläinen[2], U. Hynönen[3], M. Torkkeli[1], P. Engelhardt[4], A. Palva[3] and R. Serimaa[1]

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The Structure of The Bacterial Cell Wall and the Native S-layer

Bacteria are divided into Gram-positive and negative according to the structure of their cell wall. The cell wall of Gram-positive bacteria consists of an inner plasma membrane and an outer, 20-80 nm thick peptidoglycan layer, called the sacculus. Gram-negative bacteria have a thinner peptidoglycan sandwiched between two plasma membranes.
Some bacteria have a crystalline protein layer (S-layer) on top of the peptidoglycan. We have studied several probiotic Gram-positive bacteria, e.g. *Lactobacillus brevis* ATCC 8287, as well as the Gram-negative *Escherichia coli* DH5α, by small-angle X-ray scattering (SAXS) and transmission electron microscopy. We have also studied the Slayer of *L. brevis* ATCC 8287, due to the bacterium being identified as a potential vaccine carrier. [1]
All SAXS-patterns of Gram-positive bacteria display a prominent peak at q=0.01-0.02 Å^{-1}. This peak also appears in the intensity of *L. brevis* stripped with guanidine hydrochloride and appears to originate from the thickness of the cell wall. The Gramnegative sample with its thinner cell wall does not have a peak in this region.
Transmission electron micrographs show that the cell walls of stripped *L. brevis* were on average thicker than those of native samples. Cell walls are stained in two distinct zones, the inner and outer wall zone. Previously the inner wall zone has been termed the periplasmic space. [2] Comparing SAXS and transmission electron microscopy results suggest the inner wall zone has a similar electron density as the outer wall zone.
The SAXS intensity of native *L. brevis* samples did not contain enough diffraction peaks for the structure to be determined. However, the diffraction patterns from cell wall fragments showed clear crystalline order. We found an oblique structure with lattice constants of 84 Å and 58 Å with an angle of 78° to be the best fit. This agrees with the micrographs. We suggest the S-layer in native samples is paracrystalline, and two dimensional order appears when the cell wall is relaxed as the bacteria are fragmented.

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[2] V. R. F. Matias and T. J. Beveridge, Mol. Microbiol. 56 (2005) 240.

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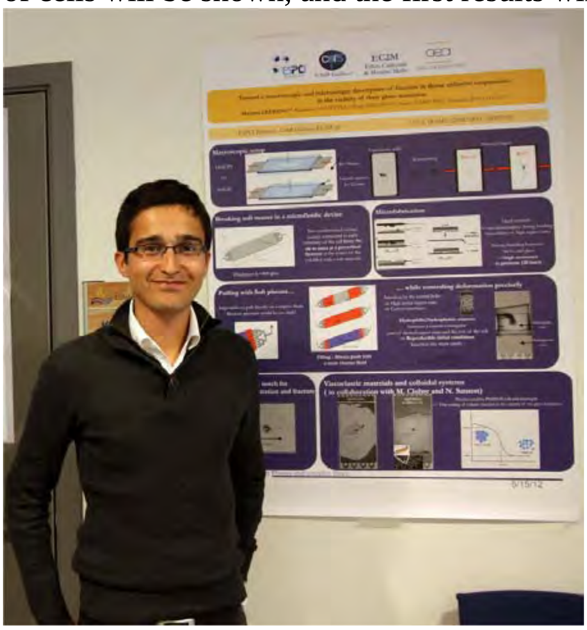
Toward a macroscopic and microscopic description of fracture in dense colloidal suspensions in the vicinity of their glass transition.

I will present two systems, which, at very different scales, are aiming at testing the mechanical response of a material undergoing a liquid to solid transition (sol-gel transition, glass transition).
The first one is a "macroscopic" Hele-Shaw cell is closed at all ends, but two of them are mobile pistons which can be pulled at a prescribed velocity. A hole is made in the upper plate, so that air can enter the cell when the pistons are pulled. In a Newtonian fluid, a circular bubble grows at the center of the cell, ending up with a typical Saffman Taylor shape. In contrast, for an agar gel, a mode I crack grows perpendicular to the direction of traction of the pistons. With a viscoelastic material, we did observe a transition between a liquid-like response (bubbles) and a solid like pattern (Mode I fracture), depending on the velocity of the pistons.
In order to be able to analyze in more details the response of dense colloidal suspensions - typically poly-NIPA suspensions - undergoing a glass transition, we are also currently building up microfluidic devices, with which experiments similar to the ones described above can be conducted at a millimetric scale. Our scope is double: the experimental setup must enable us to analyse both the macroscopic properties of the produced cracks (speed, shape of the tip, branching, healing) and some of their microscopic features (rearrangements of colloids at the tip, visualisation of the plastic zone, microscopic fracture paths). Several types of cells will be shown, and the first results will be discussed.



Maxime Lefranc

Elisabeth Lindbo Hansen[†], H. Hemmen[†], D. M. Fonseca[†‖], C. Coutant[+], K. D. Knudsen*, T. S. Plivelic[§], D. Bonn**, J. O. Fossum[†‡]

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Swelling transition of a clay induced by heating

Clays are of paramount importance for soil stability[1], but also in a wide variety of applications ranging from oil recovery[2] to composites[3] and pharmaceutics[4]. Generically, clays are divided into two subclasses: macroscopically swelling, 'active' clays that have the capacity for taking up large amounts of water to form stable gels, and 'passive' or non-swelling clays; the former stabilize soils whereas the latter are known to lead to landslides[5]. However, it has been unclear so far what mechanisms underlie clay swelling. Here, we report the first observation of a temperature-induced transition from a passive to an active, swelling clay, revealed by the use of x-ray scattering, rheology and conductivity measurements. This allows us to propose a simple description of the swelling transition. While net attractive van der Waals and electrostatic interactions are dominant at room temperature so that the clay particles remain attached to each other in stacks, at higher temperatures it is energetically favourable for the clay to swell due to the entropy that is gained by counterions that are liberated when the clay disperses in water.

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[2]Anderson, R. L. *et al.* Clay swelling - A challenge in the oilfield. *Earth-Sci. Rev.* **98**, 201-216 (2010).
[3]Bitinis, N., Hernandez, M., Verdejo, R., Kenny, J. M. & Lopez-Manchado, M. A. Recent Advances in Clay/Polymer Nanocomposites. *Adv. Mater.* **23**, 5229-5236 (2011).
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Combined voltage and magneto-optical study of the vortex flow in superconducting films

Superconductivity is going to play special role in the development of the economy based on the renewable energy resources. The combination of superconductivity with liquid hydrogen would provide CO_2 emissions-free alternative to fossil fuels [1]. To achieve this, the details of the magnetic flux flow in the superconductors must be known in the minute details. This flow is however not trivial and very far from being completely understood. While usually it is slow, in the range of millimeters per second, it can be self-driven out of equilibrium developing speed of hundreds kilometers per second and strongly affecting superconductivity in the sample. Such dramatic effects take place in a short time that it is out of the resolution of regular imaging equipment. The advanced laser techniques revealed that characteristic time scale for the development of instabilities is in the range of nanoseconds. The obtained information is sufficient for the advanced modeling of the process. However, exact input parameters required for the models are still not known, and they need be extracted on the nanoseconds time scale.
To obtain information about the time variation of electrical field during the development of instabilities, the combined voltage and magneto-optical imaging (MOI) [2,3] study of the flux flow in NbN superconducting films has been performed. Measuring voltage during the development of the vortex avalanches is a difficult task due to the extreme shunting properties of the superconductor. To overcome this difficulty, a large Cu contact pad was deposited over the half of superconducting film and the voltage was measured when the instability was developed below the contact pad. The exact position of the instability was monitored by MOI during the voltage measurements. Using this technique, first nanoseconds scale voltage profiles of the instabilities has been obtained. Several effects have been observed including the oscillations of the electrical field preceding the avalanche. A speed of flux propagation of about 100 kilometers per second has been confirmed.

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3. P.E. Goa, H. Hauglin, A.A.F. Olsen, M. Baziljevich and T. H. Johansen, Rev. Sci. Instrum. 74, 141-146 (2003)

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Numerical Studies of Aeorfractures in Porous Media

Hydraulic fractures are a result when diverse materials break under the stress induced by fluids or gases. Understanding how hydraulic fracturing is initiated and progresses is of fundamental importance whenever safe dams are constructed, super-critical CO2 stored or sustainable wells drilled. Volcanic dikes and sills arise naturally by hydraulic fracturing processes. Just as we learn to protect ourselves from the unwanted effects of hydraulic fractures it has been proven to be a useful technology to fracture the reservoir rock formations around a well-bore to enhance the recovery of mineral oil and natural gas.
In our study a dense but permeable two-dimensional (2D) granular layer is fractured by an imposed pressure gradient of the compressible interstitial gas inside a rectangular Hele-Shaw cell. For this purpose the pressure at the inlet of the cell is increased while at the opposing side a semipermeable boundary only lets the gas-phase pass through. A discrete numerical molecular dynamics model is employed to investigate the dynamics of the fractures and fingers in the granular phase. Systematic variation of the controlling parameters of the interstitial gas reveals a transition of the emerging granular displacement patterns. In the progress we can identify and describe a mechanism which controls the transition of the emerging displacement patterns from fractures and fingers to bubbles as a function of the interstitial gas properties and the characteristics of the granular phase.

Luiza Angheluta and Michael Niebling

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Solid State Structural Characterization of Biobased Materials

Protein-base materials have an interesting potential in industrial applications due to his ability to bring different kind of polymer networks. However, the processing conditions and the addition of different chemical additives, induce large structural and rheological changes which need to be carefully understood to functionalize their properties.
In the present work, we show results of the solid state structure of wheat gluten (WG) proteins films and foams mainly characterized by synchrotron x-ray scattering techniques.
Extruded WG base films with different chemical bases present supramolecular arrangements with dissimilar mechanical and oxygen barrier properties [1]. One of them, NH_4OH films, showed bidimensional hexagonal close-packed (HCP) structure altered by presence of denaturant and plasticizers agents. The temperature dependence of such structure is also analyzed.
WG protein fraction foams seem to present less organized structures, but strongly linked to their protein composition [2]. One correlation peak with d-values 40-43Å was only observed when gliadin rich aggregates were present. Glutenin rich foams doesn´t show significant structural features in the nanometric scale.

[1] R. Kuktaite, T. Plivelic, et al., *Biomacromolecules* 12 (2011) 1438.
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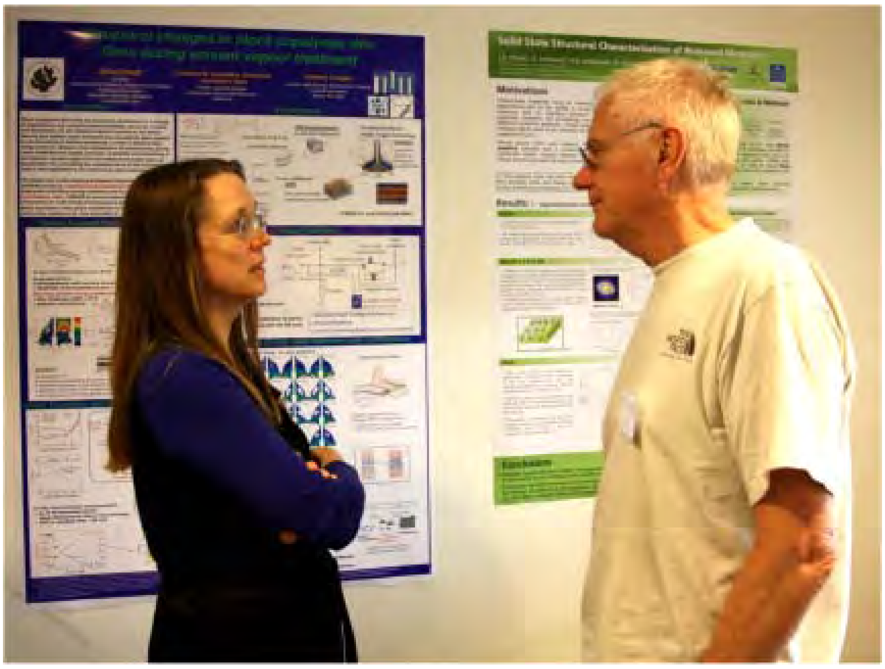

Dorthe Posselt and Roger Pynn

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Structural changes in block copolymer thin films during solvent vapour treatment

The morphologies formed in diblock copolymer thin films are useful for a number of nanotechnology applications, such as molecular sieves, templates or sensors. However, samples prepared by spin-coating have a number of defects and annealing is necessary to improve the quality. While thermal annealing may result in a chemical degradation of the polymer and application of an electric field only works in special cases, solvent annealing offers a simple and flexible method with a potentially high degree of controllability through careful choice of solvent and partial vapour pressure as function of time. The rearrangement processes during vapour treatment of block copolymer thin films are complex. The solvent not only swells the polymers, but also increases the chain mobility and reduces the interfacial tension between the blocks.

We have investigated thin films of lamellar poly(styrene-*b*-butadiene) (PSPB) which were vapour treated with toluene, a good and non-selective solvent [1] or with cyclohexane [2,3], a slightly PB selective solvent. Time resolved grazing-incidence small-angle x-ray scattering (GISAXS) enabled us to follow the changes of the inner film structure in-situ. I.e. the swelling and the rearrangement of the lamellae were investigated with a time resolution of a few seconds, and the underlying processes on the molecular level were identified.

When solvent vapour enters the film, the lamellae swell linearly, and the blocks stretch uniaxially. Then, the blocks relax to a more Gaussian molecular conformation, and the lamellar thickness abruptly shrinks again. The increased interfacial area culminates in an instability causing a major rearrangement of the lamellar stack and the formation of new lamellae. Finally, the lamellar thickness approaches a steady-state value, and the interfaces flatten again. Prolonged treatment with solvent vapour leads to disordering.

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[3] Zhenyu Di, Dorthe Posselt, Detlef-M. Smilgies, Ruipeng Li, Markus Rauscher, Igor I. Potemkin, Christine M. Papadakis, To be published

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Soil Clay Oil Suspensions Subjected to Electric Field

Electric-field-induced structuring from two types of clay particles belonging to the kaolin group of minerals, namely kaolinite and halloysite, was studied in respect to the electrorheological response of silicone oil and paraffin dispersions of both clays. Firstly, the structural and morphological properties of both types of clays were probed in detail by means of XRD, FTIR, SEM, TEM, TGA techniques. The second part of the work was related to study of dipolar arrangement induced from both types of clay particles under application of electric field and resulting interparticle structuring. This was investigated by means of WAXS with a support of optical microscopy techniques. In the third part, the electrorheological response of the samples was measured. Well-structured kaolinite particle dispersions were found to have an improved electro-rheological response relative to dispersions of the less-structured halloysite particles. Finally, the electrical currents of these ER-fluids were measured and the results revealed differences in the magnitude between halloysite- and kaolinite-based silicone oil dispersions.
The recommended literature to the following main subjects: electric-field induced structuring from clays [1-3], electrorheological properties of clays [4-5].

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[4] B. Wang et al, *J. Mater. Chem*. **19,** 1816 (2009).
[5] Y. Méheust et al, *J. Rheol.* **55**, 809 (2011).

Zbigniew Rozynek receives 3rd place (2nd runner up) poster award from the Poster Award Committee President Ivar Giaever (The other committee members were Torstein Jøssang and Heloisa Bordallo).

Award:
Diploma + 25 grams of dried codfish

Baudouin Saintyves[1], O. Dauchot[2], E. Bouchaud[1,2]

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Bulk fingering instabilities in a soft solid and in a complex fluid

Instabilities in viscous liquids confined in Hele-Shaw cells have attracted considerable attention during the past. On the contrary, instabilities arising in soft elastic materials have only started to be studied much more recently. In most cases, fingering in confined elastomers arises at the interface with an elastic plate: Interfacial crack fronts lose their stability due to a competition between bulk and surface effects.
We present here a bulk fingering instability arising in a hyperelastic polyacrylamid gel.
Experiments are performed in two types of Hele-Shaw cells: One is the classical setup used for studying liquids, and the other one has mobile sides which can be pulled at a prescribed velocity. In both cases, an instability is observed when the strain exceeds a critical value which is independent of the gel shear modulus. By colouring the material, we were able to show that fingers grow within the thickness of the cell, leaving behind layers of gels sticking to the upper and lower glass plates. It is shown that the wavelength (width of the fingers) increases non linearly with the spacing of the latter. Finally, at a later stage, when these layers are stretched beyond the fracture threshold, an interfacial crack nucleates and propagates, at a strain which depends on the shear modulus.
Similar instability is observed in a Maxwell liquid constituted by oil-in-water droplet microemulsion where the drops are connected to each other by a telechelic polymer. In this case, the critical strain depends on the flow rate.

Baudouin Saintyves receives 1st place (winner) poster award from the Poster Award Committee President Ivar Giaever (The other committee members were Torstein Jøssang and Heloisa Bordallo). **Award: Diploma + 100 grams of dried codfish.**

Bjørnar Sandnes

Multidisciplinary Nanotechnology Centre, College of Engineering, Swansea University, Singleton Park, Swansea SA2 8PP, UK

Pattern palette for complex fluid flows

From landslides to oil and gas recovery to the squeeze of a toothpaste tube, flowing complex fluids are everywhere around us in nature and engineering. That is not to say, though, that they are always well understood. The dissipative interactions, through friction and inelastic collisions, often give rise to nonlinear dynamics and complexity manifested in pattern formation on large scales

The images displayed on this poster illustrate the diverse morphologies found in multiphase flows involving wet granular material: Air is injected into a generic mixture of granular material and fluid contained in a 500 µm gap between two parallel glass plates. At low injection rates, friction between the grains - glass beads averaging 100 µm in diameter - dominates the rheology, producing “stick-slip bubbles” and labyrinthine frictional fingering. A transition to various other morphologies, including “corals” and viscous fingers, emerges for increasing injection rate. At sufficiently high granular packing fractions, the material behaves like a deformable, porous solid, and the air rips through in sudden fractures.

Irep Gosen, Also Jesorka and Bjørnar Sandnes

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Self-assembly and symbolic dynamics

Self-assembly is scientifically interesting and technologically important in fields ranging from biological systems and synthesis of materials and condensed matter science to generation of nanostructures forming mesoscopic and macroscopic components. These last points make this principle a powerful bottom-up method for nanotechnology.

A particularly interesting method to the self-assembly of nano - to millimeter - sized components is the use of the “magnetic hole” principle. In this method, nonmagnetic particles can be manipulated by external magnetic fields by immersing them in a dispersion of colloidal, magnetic nanoparticles, denoted ferrofluids. Nonmagnetic particles in magnetized ferrofluids are in many ways ideal model systems to test various forms of particle self-assembly and dynamics.

Some case studies to be reviewed include the self-assembly of viruses and the use of symbolic dynamics to describe the dynamics and self-assembly of microparticles.

Arne Skjeltorp

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Dynamic Light Scattering measurements of clay materials in liquid CO_2

Dynamic Light Scattering is an increasingly more used technique to study nanomaterials (10-1000nm) in different solvents. DLS is very simple, fast and convenient technique. It allows obtaining absolute measurements of several parameters of interest, like molecular weight, radius of gyration, translational diffusion constant and so on, it also has modest development costs.
To study different nanomaterials we used the CO_2 cell primarily designated for SANS measurements. The design of the CO_2 cell allowed us to apply the DLS in backscattering mode. In backscattering mode the angle between the incident light beam and the scattered light was in the range of 140-175 degrees. The CO_2 cell allows studying materials at different pressure and temperature conditions, including liquid and supercritical state of CO_2, up to 150°C and CO_2 pressures up to 414 bar. In addition, which is important for us, one may use different non-aggressive solvents (water and heavy water, alcohols or liquid CO_2).
The cell is designed to study materials like caprock or clays for geologic storage of CO_2. CO_2 storage in deep geological structures is a complex physico-chemical process and the geometry of pore space (pore size distribution and total porosity) is important characteristic of these materials. The DLS technique could help to understand the thermodynamic behavior of clay particles interacting with liquid CO_2 and can be used as complementary technique with SANS.
Our present research focuses on physical processes that are of importance for the optimization and understanding of CO_2 transport into the ground. The relevant geological structures may show large variations in composition (water saturated porous materials, such as sandstone in a sedimentary basin, caprock, clays). CO_2 trapped in such porous materials relies on different mechanisms of confinement that act on different time scales. Some important factors to consider are: 1) an impermeable caprock that keeps the fluid underground (supercritical CO_2 fluid), 2) the solubility of the CO_2 in the water, 3) intercalation (absorption) into clay nanopores, 4) chemical reactions that bind the carbon in mineral form to the rock.
To validate the application of the CO_2 cell for the DLS measurements, polystyrene spheres (100nm and 200nm in diameter) were used. The results showed good agreement between the diameter calculated from DLS and the nominal value..
Preliminary DLS measurements of laponite clay in H_2O showed satisfying agreement of particle dimensions and hydrodynamic properties with the expected values. The measurements in liquid CO_2 were harder to perform because the CO_2 viscosity is two orders of magnitude lower then water, causing faster sedimentation of clay particles. Nevertheless, results obtained from clay particles in CO_2 are promising.

Pawel Sobas

Ken Tore Tallakstad

Physics Department, University of Oslo, Norway

The survival of fat tail exponents during up-scaling in disordered interface systems

In any disordered system, with a steadily propagating interface, it is clear that the variance of the local velocity distribution will diverge if it possesses a fat-tail, with a power-law exponent $1+\alpha > 3$. We show that the distribution of the velocity, when it is spatially averaged over larger and larger scales, does not converge to a Gaussian, but rather to a so called stable distribution, characterized by α and an asymmetry parameter β. This is predicted by the generalized version of the central limit theorem in the case of an infinite variance. Our study aims to underline the importance of this generalized central limit theorem in the context of uncorrelated non-Gaussian statistics for averaged variables, in systems where local information is unavailable.

Renaud Toussaint, F Cornet

Institut de Physique du Globe de Strasbourg, University of Strasbourg/CNRS

Influence of chemistry and climate on large induced large scale stresses in anisotropically fractured carbonates.

Max Wolff

Division for Materials Physics, Department for Physics and Astronomy, Uppsala University, Uppsala, Sweden

The solid-liquid boundary as seen by scattering

On the molecular scale the solid-liquid boundary is difficult to probe directly and non-destructively. As an example AFM, SFA or optical techniques need direct contact to the surface or tracer particles, respectively. On the other hand it has been shown that scattering techniques are an excellent possibility to contribute in this context, since they are non invasive and non destructive, with minimum perturbation of the sample. In particular a combination of x-ray, high intensity and resolution, and neutron scattering, sensitivity to light elements and dynamics, is highly valuable.

We have investigated the solid-liquid boundary condition in flowing hexadecane in contact with differently functionalized solid surfaces with NR. Hexadecane is known to exhibit large interface slip with slip lengths, i.e. the imaginary position of the wall assuming no surface slip, ranging from 110 - 350 nm. We establish a connection between the depletion layer and the interfacial energy that contradicts the explanation of slippage by a density depleted layer.

For a low molecular weight polystyrene (PS) largely different slip length were found on self-assembled monolayers (SAMs) of different chain length. A combined X-ray and neutron reflectivity study relates this effect to in-plane correlation of the SAM. This points out that slippage of oligomers is driven by a conformational change of the liquid near the interface rather than by a mere density depletion.

Additionally, for a system of polymer micelles the use of grazing incidence and spin echo techniques will be discussed.

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Lofoten, Norway May 22-25, 2012

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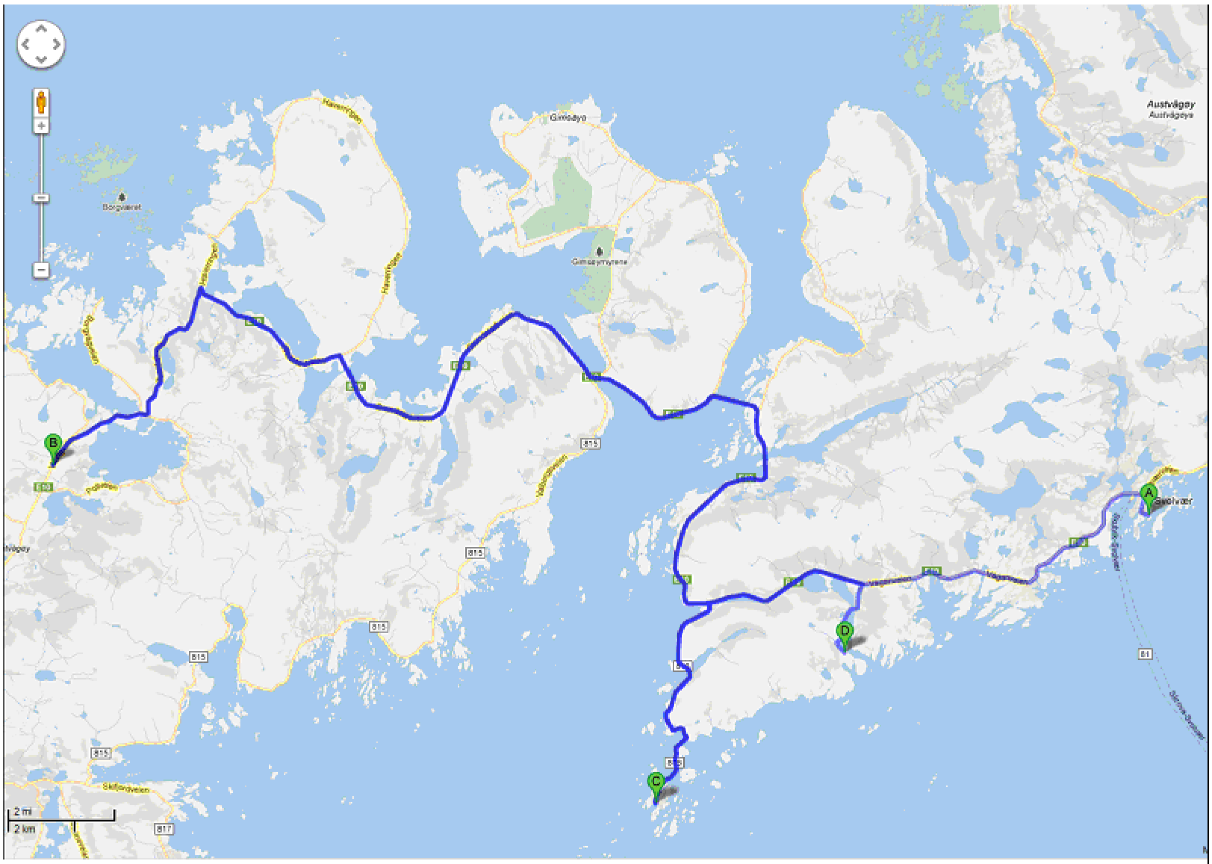
A: Workshop venue: Thon Hotel Svolvær

24/5 2012 Afternoon Excursion:

A: Thon Hotel Svolvær
B: Lofotr Viking Farm (A-B: 1 hour drive)
C: Henningsvær (Fishingvillage) (B-C: 45 minutes drive)
D: Kalle (Old trading post) (C-D: 15 minutes drive)



Lofotr Viking Farm:

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International Workshop on Soft Matter Physics & Complex Flows
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ISBN 978-82-93224-11-2

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